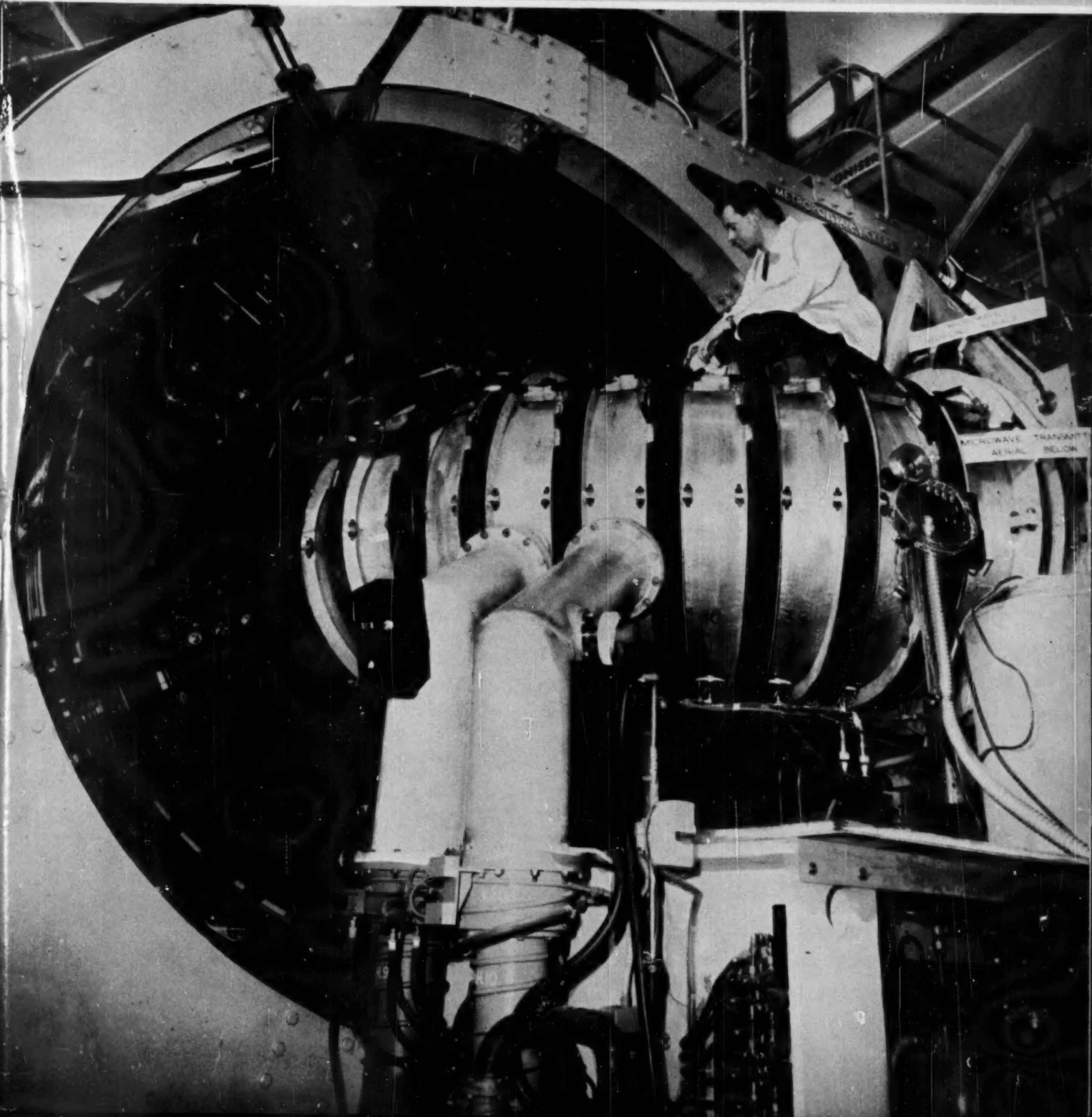
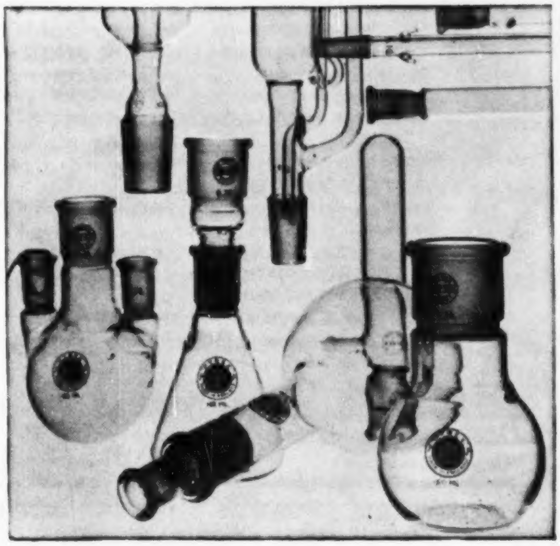
DISCOVERY

MARCH 1958 2/6





DISCOVERY

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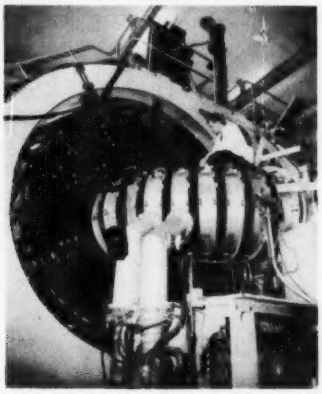


A scientist at Harwell inspecting the torus of ZETA which is fully described on pp. 89–92

CONTENTS

THE PROGRESS OF ATOMIC SCIENCE

HARWELL'S GREATEST MILLISECOND

It was officially announced in Great Britain and the United States, on January 24, 1958, that ZETA first went into operation on August 12, 1957, and that it produced neutrons for the first time on August 30. Deuterium gas was electrically heated to 2–5 million degrees C, and bursts of neutrons occurred during milliseconds at 10-second intervals. This date must be considered as the true beginning of nuclear fusion reactions, and although similar but smaller reactions had been observed previously, it is due to the ring-shaped tube, or torus, of ZETA that success was achieved. That these successful experiments at Harwell "preceded this (U.S.) work by several months" is gladly admitted by J. Honsaker *et alii** in the description of the work at the Los Alamos Scientific Laboratory along similar lines. Their much smaller doughnut-shaped tube, the Perhapsatron S-3, came into operation only during December 1957. In view of the widely circulated speculations about these dates, it is to be regretted that these facts were not openly stated. It is only to be expected that in future some new advances will come from the American laboratories working in this exciting new field of nuclear research. If harmonious collaboration is to succeed, then surely each team is entitled to its claim of priority, the long-established and generally accepted etiquette amongst scientists. To publish scientific advances at politically convenient dates is surely not an innovation which will meet with general approval. Harwell deserves unstinted congratulations for its greatest achievement so far; and in their publications American scientists are fully conscious of this.

How far Russian research workers have progressed in this field, is at present completely unknown. However, in

* *Nature*, 1958, vol. 181, p. 231.

FIG. 1. One of the first. Senior Scientific Officer C. E. Vance, at work in the Birdcage Laboratory (small torus laboratory) on one of the first metal tori to be constructed at the AERE, Harwell. The coils on the outside of the torus are used to examine the discharge induced in the gas it contains. The discharge can be seen by looking into a mirror through a slit in the torus.

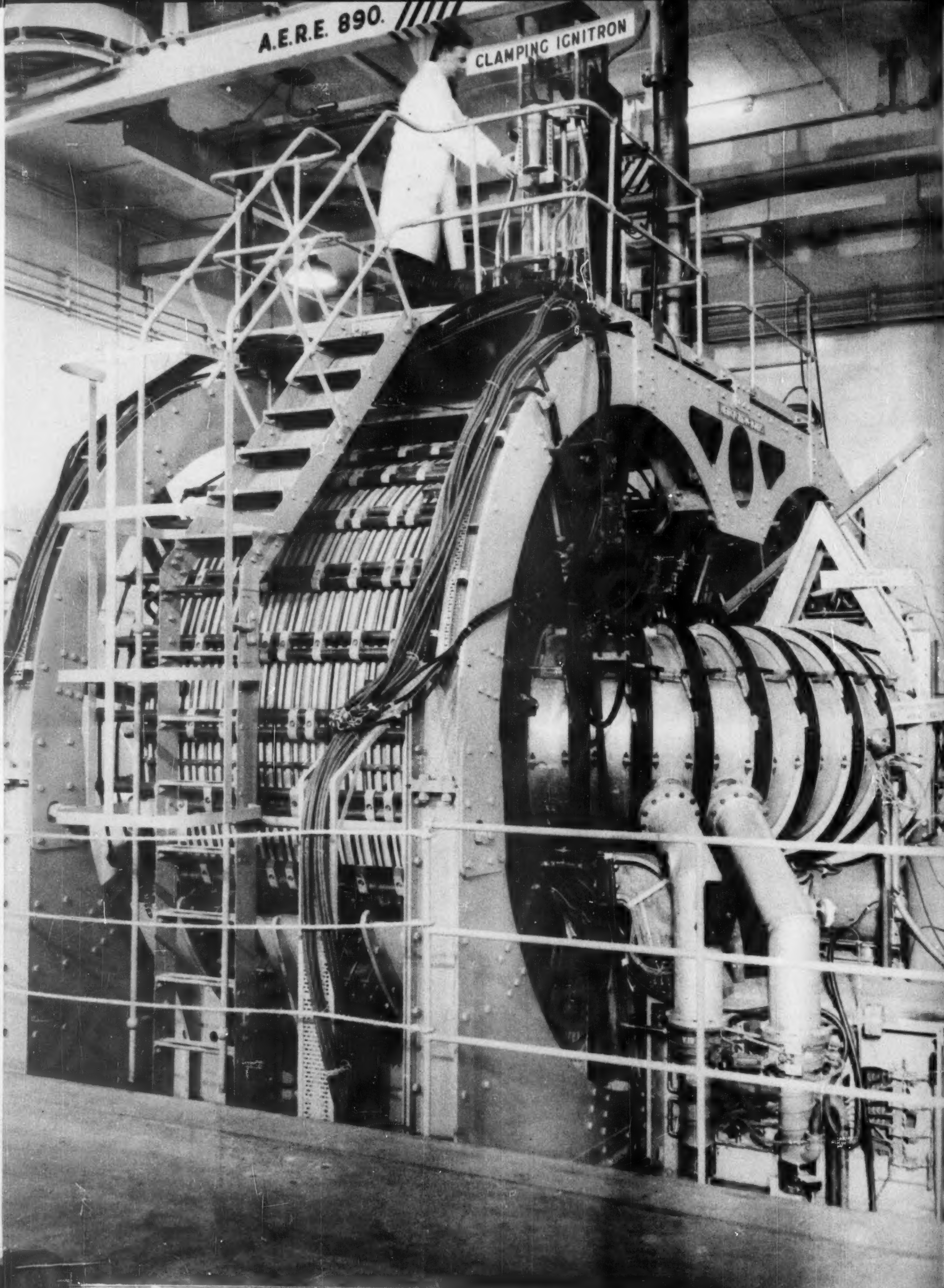
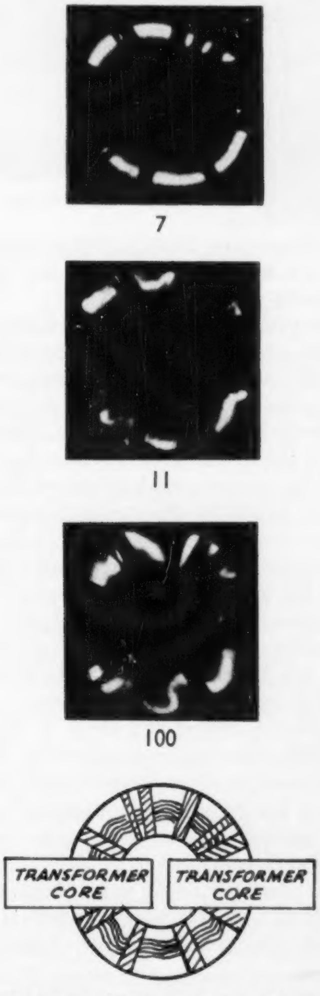

A.E.R.E. 890.
CLAMPING IGNITRON

FIG. 2. ZETA: A side view of the torus and transformer. The torus is an aluminium tube with a bore of 1 metre, and a special internal design to avoid electrical breakdown troubles. The pressure is kept very low by continuous pumping, and heavy hydrogen flows through at a pressure of about 1/10,000 mm. The gas is weakly ionised by a radio-frequency oscillator. Capacitors holding 500,000 joules (0·14 kWh.) are discharged into the primary winding of the transformer coils round the torus; the torus itself acts as the secondary winding of the transformer. Currents exceeding 200,000 amperes are consequently produced in the gas. The magnetic field coils on the outside of the torus (and its metal construction) help to stabilise the discharge, thus preventing it from touching the walls, the so-called "wriggle".



Times from start of discharge in millionths of a second

FIG. 3. Sceptre III. Photographs of a 200 ampere argon discharge in a glass torus showing its development at various times, given in microseconds. No magnetic stabilising field was present for the above photographs which were taken by A.E.I.

view of their advanced state of thermonuclear research as far back as May 1956 (DISCOVERY, 1956, vol. 17, p. 227), the publication of Russian work will be awaited with more than the usual interest.

ZETA'S Results. Research at Harwell with this apparatus has led British scientists to the conclusion that control of thermonuclear reactions for electricity generation may well be a possibility for the future, though its practical application is still a long way off. The possibility now being explored is the harnessing of power from the fusion (or joining) of atoms after the manner in which heat for the stars is derived.

Results obtained from Harwell's ZETA suggest that "thermonuclear neutrons" have been obtained, but further experiments will be necessary before this can be proved conclusively. Temperatures reached in this apparatus have been as high as 5 million degrees C, higher than the measured surface temperatures of any star. (About 5000°C.)

Many major problems have still to be solved before its practical application can be seriously considered and the work must be expected to remain in the research stage for many years yet. If it proves ultimately possible to construct a power station operating on the fusion of deuterium, the oceans of the world will provide a virtually inexhaustible source of fuel.

As the Atomic Energy Authority have stated in their last two annual reports, research has been in progress for some years to investigate the possibility of producing energy in a controlled manner from thermonuclear reactions. Over two years ago, work began on the design of a large installation for this task. Neutrons emitted in the first successful reactions of August 30, 1957, were observed when deuterium gas was heated electrically to temperatures in the region from 2 to 5 million degrees C. The hot gas was isolated from the walls for periods of 2 to 5 thousandths of a second. The heating process was repeated every 10 seconds. The high temperatures achieved, together with the relatively long duration for which the hot gas has been isolated from the tube walls, are the most important experimental results obtained so far. Much longer times (perhaps several seconds) are required for a useful power output but there appears to be no fundamental reason why these longer times, together with much higher temperatures, cannot be achieved.

The source of the observed neutrons has not yet been definitely established. There are good reasons to think that they come from thermonuclear reactions, but they could also come from other reactions such as collision of deuterons with the walls of the vessel, or from bombardment of stationary ions by deuterons accelerated by internal electric fields produced in some forms of unstable discharge.

In ZETA the number of neutrons produced by each pulse of energy, as the current was doubled, was roughly that which might be expected from a thermonuclear reaction at the measured temperatures. These temperatures have been definitely established.

The Principle of ZETA. The reaction being studied in ZETA (Zero Energy Thermonuclear Assembly) is that in which deuterons (nuclei of the heavy hydrogen isotope deuterium) collide with one another and fuse to form

heavier nuclei, releasing energy and some neutrons in the process. For fusion to be possible the deuterons must have enough energy to overcome the initial electrical forces of repulsion between them; this necessitates heating the deuterium gas to temperatures of millions of degrees C. The hot gas must be kept away from the walls of the container otherwise the plasma, the hot gas, would be cooled.

The principle adopted in ZETA is to pass a large electric current through the deuterium gas. This current sets up an electric discharge in the gas (analogous to the discharge in a neon advertising sign) which heats it and also produces an intense magnetic field around the column of hot gas. This magnetic field causes the discharge to become constricted and hence heated still more. Since it also causes the discharge to wriggle about, this field by itself is not enough to keep the discharge away from the walls. The wriggling has been suppressed by applying an additional steady magnetic field parallel to the axis of the tube. To achieve this steady state required exhaustive research.

In ZETA the discharge chamber is a ring-shaped tube, or torus, of 1 m. bore and 3 m. mean diameter, containing deuterium gas at low pressure. The tube is linked (that is, encircled over part of its length) by the iron core of a large pulse transformer. A current pulse of electricity is passed into the primary winding of the transformer from a bank of capacitors capable of storing 500,000 joules of energy. This pulse in turn induces a very large unidirectional pulse of current in the gas which forms a short-circuited secondary for the transformer. Peak currents up to 200,000 amp. have been passed through the ionised gas for periods up to 5 milliseconds. The current pulse is repeated every 10 seconds. Emission of neutrons throughout the current pulse is observed regularly in routine operation of ZETA with deuterium; there are up to 3 million neutrons emitted per pulse.

ZETA's Future. The temperature of gas discharges may be determined from measurements on the light emitted by the gas atoms. But measurements of this kind in these experiments present problems because, at the temperature of the discharge, the hot deuterium atoms are completely stripped of their electrons and therefore do not emit a line spectrum. One method of solving this problem is to mix with the deuterium a small quantity of some heavier gas, such as oxygen or nitrogen, the atoms of which are not stripped of all their electrons under these conditions, and to study the spectral lines emitted by this impurity; the random motion of the high-energy impurity atoms which make many collisions with the deuterium atoms and so reach the same energy, causes the spectral lines to broaden, owing to the Doppler effect, and the amount of broadening is a measure of the ion energy. Many measurements by this method have indicated temperatures in the region of 2 to 5 million degrees C. Temperatures in this range are required to explain the observed rate of neutron production on the basis of a thermonuclear process, but electric fields in the gas arising from instabilities can also accelerate deuterium ions and lead to nuclear reactions. Such a process was described by Academician Kurchatov in his lecture at Harwell in 1956. (See DISCOVERY, 1956, vol. 17, p. 227.) Therefore it is not altogether certain that the

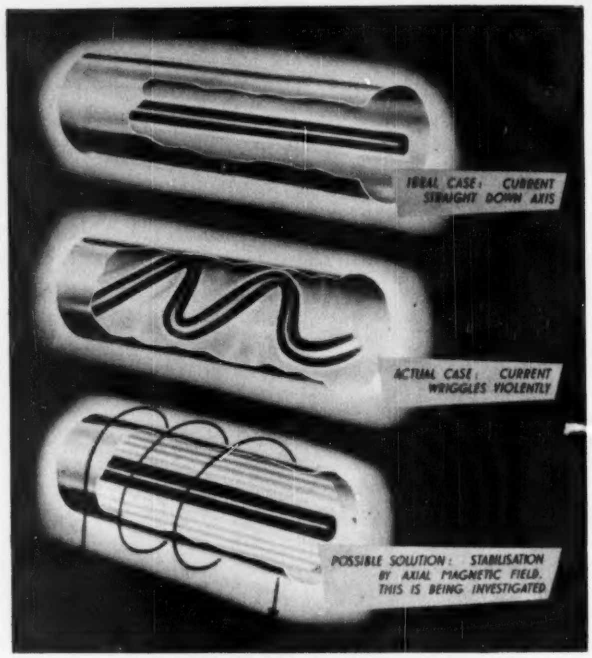


FIG. 4. Principal Difficulty: The "Wriggle".

observed neutrons come from a thermonuclear reaction. Experiments are continuing to study the details of the neutron-producing processes.

Many major problems still to be solved before its practical application can be seriously considered and the work must be expected to remain in the research stage for many years yet. In order to obtain a net gain in energy from the reaction it would be necessary to heat deuterium gas to temperatures in the region of 100 million degrees C, and to maintain it at this temperature long enough for the nuclear energy released to exceed the energy needed to heat the fuel and to compensate for that lost by radiation. Lower temperatures would suffice for a deuterium-tritium mixture.

The Credit for ZETA. The work on ZETA has been done in the General Physics Division at Harwell which is under the direction of Mr D. W. Fry. The group responsible for the work has been led by Dr P. C. Thonemann, an Australian, and senior members concerned with ZETA have been Mr R. Carruthers and Mr R. S. Pease, with Mr J. T. D. Mitchell of the Engineering Division, and Dr W. B. Thompson, a Canadian, of the Theoretical Physics Division. Dr Thonemann has been actively engaged in research in gas discharge physics for over ten years, first at the Clarendon Laboratory, Oxford, and since 1951 at Harwell. The principal contractors for construction were Metropolitan-Vickers Electrical Co. Ltd, who also collaborated in the design, British Insulated Callenders Cables Ltd, and Telcon Ltd.

Research work in the field of controlled thermonuclear reactions is also being carried out at the AEI Research Laboratory under the direction of Dr T. E. Allibone, F.R.S., on behalf of the Atomic Energy Authority and with the advice of Sir George Thomson, F.R.S. Experimental work was started at Imperial College by Sir George Thomson in 1947. It was moved to the AEI Laboratory in 1951. The

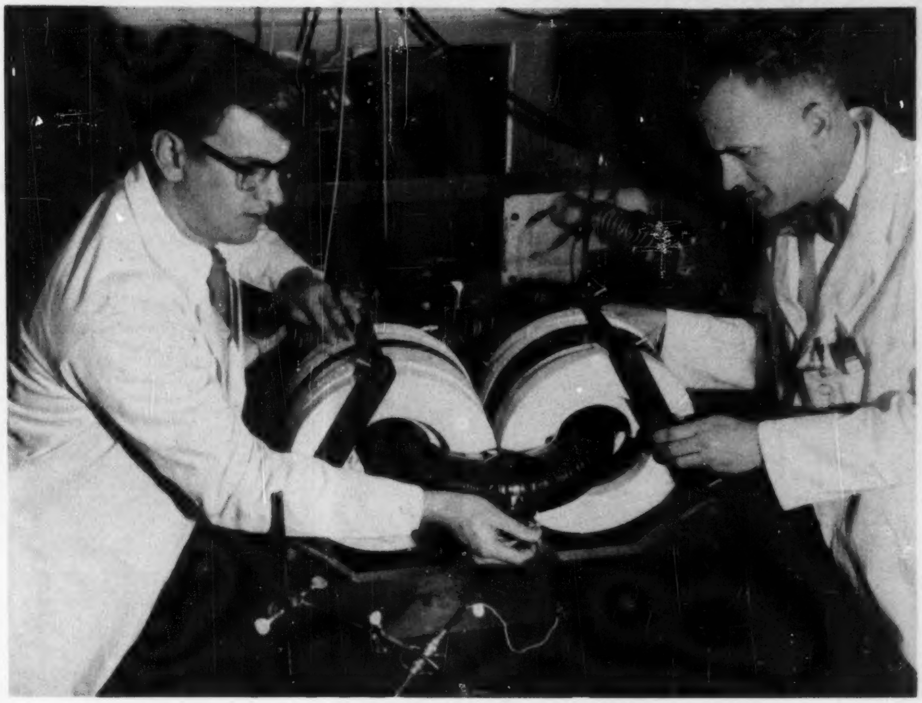


FIG. 5. The Perhapsatron. Dr John Osher (*left*) and Dr J. P. Mize prepare the American fusion apparatus for a test run at the Atomic Energy Commission Laboratory in Los Alamos, New Mexico. The Perhapsatron's torus is made of glass surrounded by copper, and is about as big as a scooter tyre. Its minor diameter is about 2 in. whereas that of ZETA is 39 in. The temperature of its pinch is higher than that of ZETA (6,000,000°C), but the pinch lasts only about a few millionths of a second (about a thousandth of the duration of pinch in ZETA).

senior members of staff engaged are Mr D. R. Chick and Dr A. A. Ware.

ROBOTS AND FROGMEN AT HARWELL

The first General Mills (U.S.A.) power manipulator to be used in this country has been installed in a new building at the Atomic Energy Research Establishment, Harwell. The one-story building was completed in January. It is designed for the housing of remote control instruments to handle highly radioactive test materials, and is equipped with five Savage and Parsons master slave manipulators in addition to the power manipulator.

The Savage and Parsons equipment, developed in collaboration with the AERE, is required for its sensitivity. It is a pair of mechanical hands which follow the hand movements of the operator who is separated from it by a wall of natural concrete 5 ft. 6 in. thick. The operator observes the tool's performance through a zinc bromide window of equal thickness (Fig. 1), but can "feel" the objects handled because the master slave manipulator works on a principle of direct feed-back.

The General Mills manipulator (Fig. 2) is required for power and for versatility. It can lift 750 lb., against the 150-lb. lift of the master slave equipment, and has an articulated arm, broader wrist movements, and up-and-down movements. Both manipulators operate by joy-sticks, but the power tool is electrically controlled and has no feed-back (Fig. 3). Pressure is indicated on a gauge or by means of electronic beeps.

The construction of the new testing plant grew out of plans for building more efficient nuclear power stations. Test loops containing analogue components of nuclear reactors are first inserted in the Materials Testing Reactors, DIDO and PLUTO, and subjected to heavy irradiation. Some of the components are left there for three months, some for six, and some for nine. After irradiation, the test loop is placed in a lead "coffin" and sent to the new building where a 25-ton crane takes it to the Transfer Bay. A 10-ton crane in the Frogmen's Operating Area transfers the "coffin" to the cells where the test loops are extracted by the manipulators to be examined for distortion and deterioration (Fig. 2).

Particular emphasis is placed in maintenance and decontamination so that each part of the plant can operate as quickly as possible. The cells, Transfer Bays, and equipment are all cleaned by maintenance men in air-tight rubber suits (Fig. 4), after the rooms have reached a suitable gamma level. These men work, on the average, 2½ hours in their suits; a longer shift results in severe exhaustion. The air supply is pumped in through ample lengths of rubber hose. The frogmen maintain contact with the service-room by telephone and through a loudspeaker which switches on the moment the phone is cradled.

The plant can accommodate radioactive materials at levels of 100,000 curies* or more. The planners wished to make the building as flexible as possible, hence the cells are separated by removable steel doors. Normally the cells are each 8 ft. wide, 10 ft. 6 in. deep, and 16 ft. 6 in. high; but the first two cells have, for the time being, been converted into one room 18 ft. wide, by the pressing of a button which operates the sliding doors. This operation takes two minutes, for the doors weigh about 30 tons and are 20 in. thick. It would be possible, when necessary, to convert the whole of the block of cells into one enormous room. The first two cells are used for reception and cross-cutting of test loops; the others, for machining, metrology, and physical testing.

There is a carefully balanced ventilation system to

* In a sample of 1 curie activity about 4×10^{10} (40,000 million) atoms break up every second to give radiation.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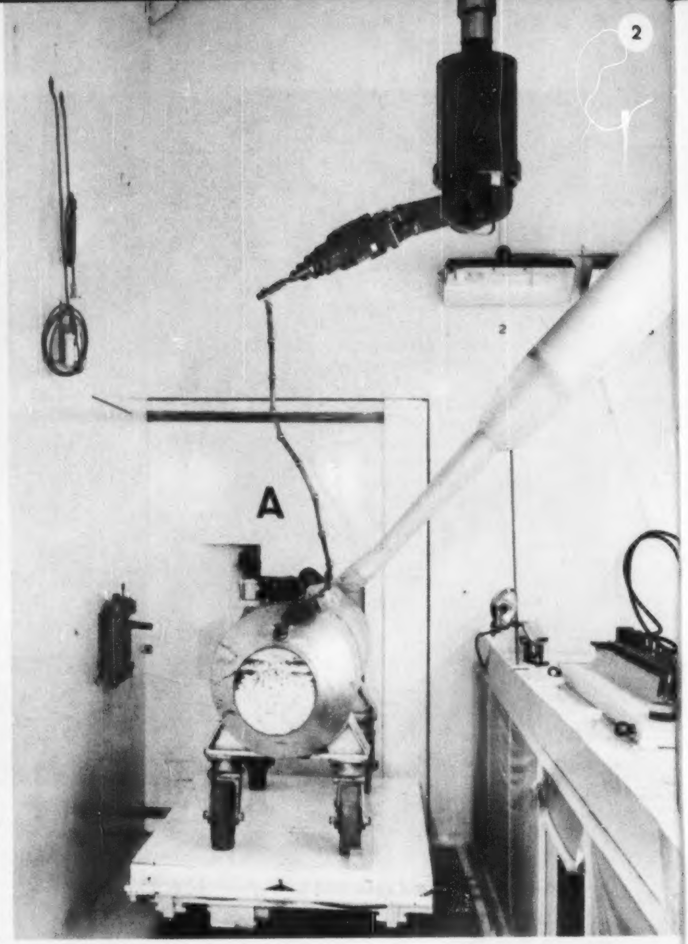
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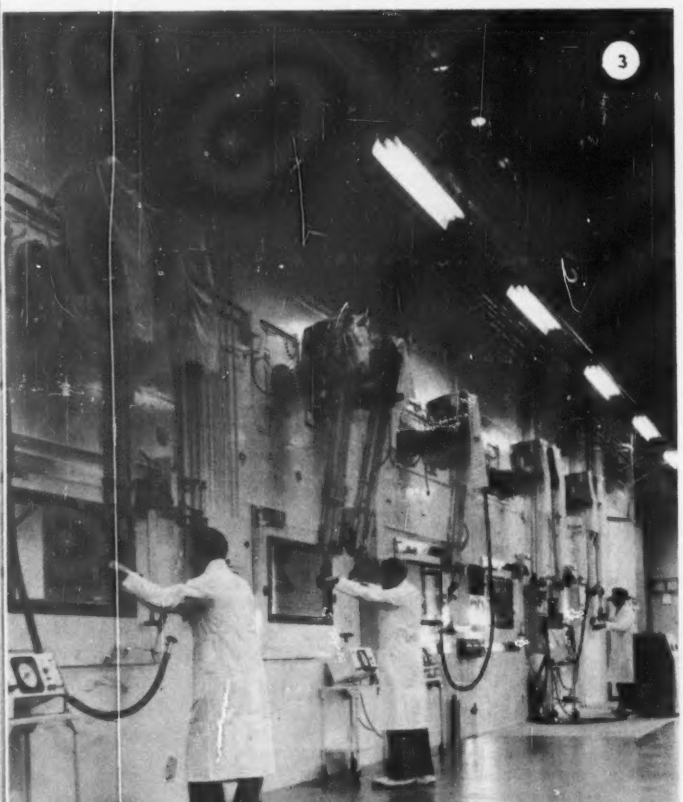
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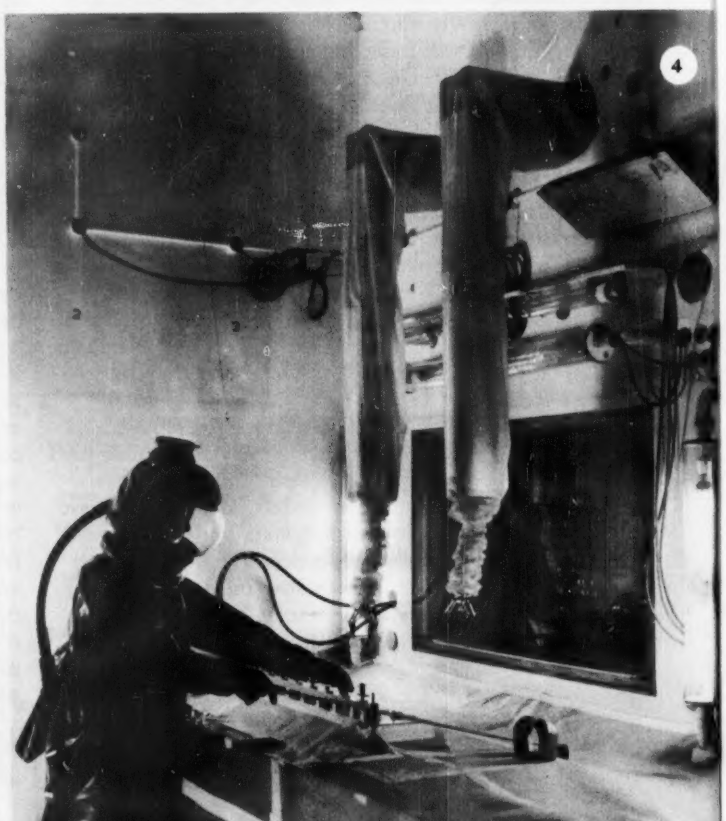
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FIG. 1. Cell interior showing operator using metrology rig. The window is 5 ft. 6 in. thick and is made of a dense solution of zinc bromide encased in fibre glass. It covers an area of 5 ft. by 3 ft., and provides the same protection from radiation as the surrounding concrete, also 5 ft. 6 in. thick.

FIG. 2. Cell interior showing power manipulator (*top right*) and master slave manipulator extracting a test circuit from a lead "coffin".

FIG. 3. View of the cell operating face. The control box for operating the power manipulator may be seen in the background. The technicians, wearing cloth "boots" to prevent outside dust from entering the building, are working the joy-sticks which operate the master slave manipulators.

FIG. 4. Frogmen decontaminating a working surface.

prevent the spread of contaminated air from the cells and service areas. The inlet and outlet systems are entirely separate; the pressure in the various areas is controlled, and the flow from the Vokes 44 filter is designed always to move *into* areas of high activity. The air extracted through the Vokes 55 is filtered twice and is 100% pure by the time it leaves the building.

HEAVY WATER

The subject of heavy water production is one of considerable interest in view of Harwell's recent announcements about ZETA. The Germans have reported plans to bring into operation a plant at Hoechst employing the hydrogen distillation process, and the French also have a plant near Toulouse which should be in operation shortly. Both these plants employ crude ammonia synthesis gas, containing about 25% nitrogen together with small amounts of impurities, as the raw material, and this is expected to result in a comparatively high production cost. This has been confirmed by studies at AERE, Harwell, where, however, some reduction in cost has been effected by the use of an improved process employing expansion turbines to produce the refrigeration, so that pressures below 10 atm., instead of around 100 atm., can be employed. Considerable theoretical and experimental work has been carried out on the Harwell process, particularly on the difficult problem of obtaining a high purity feed gas by freezing out impurities in reversing heat exchangers or "regenerators".

The position is quite different if comparatively pure hydrogen, for example, from electrolytic cells, is available as raw material. Here it is interesting to note that the Government of India have selected the hydrogen distillation process for their new plant to be erected at Nangal, where electric power from a new dam under construction is to be used to provide electrolytic hydrogen for fertiliser manufacture. The use of electrolytic hydrogen confers another advantage in that the electrolytic cells can be arranged to give a preliminary enrichment of the hydrogen feed to the distillation plant, at the expense of a small reduction in heavy water output, thus reducing the cost still further. Tenders for the Indian plant are due to be submitted shortly, and among these will be one using the basic Harwell process designed by Petrocarbon Development Ltd and Simon-Carves Ltd as engineering contractors. A further possibility in which pure hydrogen is employed is the so-called "closed-cycle" process, in which depleted hydrogen from the distillation plant is re-enriched by chemical exchange with ordinary water, thus enabling unlimited output to be obtained independently of available hydrogen supplies. The capital and operating costs are increased appreciably by the exchange step, but nevertheless the combination appears promising and is receiving close study at Harwell.

The United States process, which is used for very large-scale production, is based on a completely different principle which makes use of a dual-temperature chemical exchange between the deuterium atoms of H_2S and water. Pilot plants employing this process have been operated by the Swedish ASEA Company and also by the French, while the German Pintsk-Bamag Company is also interested in the process. It is to be noted that this process is likely to prove less economical outside the U.S.A., where very low-cost fuel is available in some areas. A theoretical study of the H_2S process has been carried out at AERE, Harwell, where a method of heat recovery has been developed which reduces operating costs appreciably, and a full-scale plant could be built immediately if required.

The dual-temperature process could also be carried out using the hydrogen-water or ammonia-hydrogen exchange reactions provided suitable liquid phase catalysts were available. It is reported from both France and Germany that some success has been obtained in the development of a catalyst for the reaction involving water, while some years ago it was found that potassamide was a suitable catalyst for the ammonia reaction. Work on the latter has been carried out at Brookhaven in the U.S.A., and, more recently, with a view to large-scale development, at Harwell. The difficulty with this process is that of obtaining a satisfactory rate of exchange of deuterium atoms between hydrogen and ammonia at temperatures around $-60°C$, but there is every hope that this will be achieved. Once this is done, it will be possible to apply this process either in "open-cycle" form, using low-grade industrial hydrogen or perhaps even town gas as raw material, or in "closed-cycle" form using water as raw material.

Although there is no heavy water plant in operation or building in this country, adequate supplies from outside sources are available for research and prototype power reactors and construction could start immediately once the requirement arose. In fact, the consequences of further delay might well be favourable, since this would allow time for studies on the remaining processes to be completed, with the resulting possibility of further reductions in the production cost.

AND YET, MAN FEARS THE ATOMIC AGE

A plan for community education in dealing with "irrational fears and irrational hopes" roused by today's nuclear projects has been initiated by the World Health Organisation (WHO). The plan calls for the formation of small local teams consisting, for example, of a psychiatrist, a psychologist, a sociologist, and a journalist, to help in the planning of new atomic enterprises and their acceptance by the public.

These proposals have been made by a WHO study group, meeting in Geneva, which has been called together to review mental health problems related to the advent of the atomic age. Specialists from fields as different as psychiatry, atomic and radiation sciences, public health, social anthropology and journalism, are engaged in this study so far, and other experts are being brought in. The group has already examined reports from many countries concerning the emotional impact of atomic energy developments as reflected in everyday life, public statements, the Press, and letters to atomic authorities or political leaders. They found that, in general, *irrational fears were expressed far more often than irrational hopes.* One reason for this, the group said, might be found in the fact that people were first made aware of radiation as a means for treating two dreaded diseases, tuberculosis and cancer. But worse, atomic energy was first used on a vast scale as a war weapon; and this action had aroused a deep sense of fear. In some people the contemplation of the atomic bomb also carried with it moral involvement and personal guilt.

But there were also other factors influencing public attitudes to atomic energy. One of them was the mysterious, almost magical aura of atomic power. Atomic radiation was invisible, unheard, unfelt, apparently infinitely powerful yet springing from an almost infinitely small source and, as far as ordinary people were concerned, it was uncontrollable. It was credited with almost infinite potentialities for both good and evil, and represented man's most amazing success in his search for power. Now, the oldest myths and legends shared by mankind since the dawn of history showed that man's quest for power often resulted in terrible divine punishment: Prometheus stealing fire from the gods, Pandora unleashing forces she could not control, Faust evoking the Devil, the alchemists of the Middle Ages, all paid a heavy penalty for their daring. These tales were found in one form or another in nearly all cultures, as witness an ancient Egyptian saying: "When man learns what moves the stars, the Sphinx will laugh and life will be destroyed."

The group also found that perhaps the most terrifying aspect of atomic energy in the popular imagination was that its tremendous power might one day soon get out of control. More recently, too, people were beginning to fear its biological reaction. "Fallout" and atomic wastes would poison the air, water, and soil, and then the plants and cattle, the men who ate them, and, above all, their children and their descendants, would all succumb to this diabolical poison. This apprehension, the WHO group has found, is a deeper and more subtle fear than that of the unleashing of energy itself that might destroy the universe.

Another quite significant finding of the WHO group is that there exists among the public what they describe as "a widespread sense of disorientation" in regard to atomic energy matters, and a deep mistrust of most information sources. For this lack of credulity there were many reasons, including wars, psychological warfare, political propaganda, and even the effects of competitive commercial advertising. Moreover, the publicising of disagreements and contradictions among scientists about polio vaccine or the cancer-producing effects of tobacco, and so forth, had also contributed to a growing mistrust of science. Although a certain section of public opinion could be relied on, for the time being, to continue to place confidence in authoritative declarations, in many countries a general distrust of scientific pronouncements was becoming the rule. In addition, in some countries the unrestrained licence of "science fiction" had so pictured the horrors of scientific power, the "death ray" and the "mad scientist", that this was the interpretation that ordinary people put on what they read and heard. This attitude formed one of the most serious obstacles in the way of establishing public confidence in the *peaceful* uses of atomic energy.

So much for the ever-mounting elements of fear. But unreasonable hopes were also taking their toll and affecting people in both the developed and the under-developed countries. Irrational expectations, the group stated, might lead not only to local dissatisfaction, but also become a real danger to the whole world. Many people were expecting immediate returns from atomic energy in terms of national prestige, and a higher standard of living which, for the first time, would put poor countries on a par with the richest countries. These people were bound to be disappointed. New ways of life and many technical changes were needed before these goals could be accomplished, and the disparity between aspirations and results could well be catastrophic and lead to further international hostility. Atomic energy developments demanded, therefore, the sanest and wisest possible handling by both scientists and governments. Although the group do not state so in specific terms, it is clear that irresponsible bragging and atomic sabre-rattling has a boomerang effect against the people who are being "protected".

The WHO experts therefore urged that the complexity of underlying emotions in the swiftly changing environment of the Atomic Age needed to be recognised more widely among leaders of thought and action. The first task seemed to be to establish what might be termed a "culture of change", in which the reorientation of the people to the new world could take place without violent upheaval. The chief effort should be to give the adults a better understanding of the new situation. But the main duty of the present generation was towards its children. Their upbringing must enable them to deal with insecurity and to face reality. This upbringing must be free from anxiety and hate, producing in individuals self-reliance and a sense of responsibility towards others. In addition, leaders in public life—doctors, teachers, the clergy, the authorities—must be educated in mental health requirements, in face of today's war hysteria.

The study group concluded its Geneva session with a number of practical suggestions concerning the public relations work to be done in connexion with atomic installations, the production of atomic power, and medical use of radiation. As regards the Press, atomic energy news was often presented under scare headlines, which contributed to the anxiety of the reading public. Journalists ought, therefore, to be educated to understand more of the implications of the news they had to handle, and atomic authorities should provide a really effective information service for the public benefit. In fact, by its outspoken report, the WHO group has itself made a vital contribution to the adaptation of mankind to the advent of atomic power.

RUDOLF DIESEL (1858–1913)

EGON LARSEN

On the morning of September 30, 1913, the Great Eastern Railway passenger boat *Dresden* steamed slowly into Harwich harbour after the night crossing from Antwerp. One of the passengers was missing. Dr Rudolf Diesel's cabin was empty, the bed had not been slept in; his watch hung from the little hook above the pillow; his nightshirt, tidily folded, lay on the blanket; his suitcase on a chair.

Rudolf Diesel, the famous German inventor and industrialist, the creator of the prime mover that bore his name, the owner of one of the most valuable patents of all times had disappeared without a trace. When his belongings were returned to his family they found his diary. There was a little cross pencilled in against the date of September 29.

In an earlier diary Rudolf Diesel has recorded for us the decisive moment in which the student of mechanics turned inventor.

> When my revered teacher, Professor Linde, told us in his thermo-dynamics lecture in 1878 that the steam engine transforms only six to ten per cent of the available heat of the fuel into actual mechanical work; when he explained Carnot's proposition that in an isothermal change of a gas *all* the available heat is turned into energy: it was then that I wrote in the margin of my notebook, "Find out if it is possible to apply isotherms in practice."

Research, however was out of the question for the young man. He had to earn a living first. Prof. Carl von Linde, his teacher, offered him a job at the Swiss factory which made refrigerators of Linde's own design. Diesel went to Winterthur, then to Paris. It was a strenuous job; he was salesman, adviser, designer, mechanic, and maintenance man rolled into one. Yet all the time the problem of the heat engine revolved in his mind.

A portrait specially drawn for DISCOVERY by Frank Horrabin. In the background is the first Diesel Engine, built 1896–7, which is now preserved in the Deutsche Museum in Munich.

THE FIRST DIESEL ENGINE

"I am thirty now," he wrote in 1888, "but I feel like an old man, and I am sad that I have achieved so little." He told Prof. Linde of his frustrations. Linde, who liked Diesel and believed in him, sent him to Berlin, where Diesel had much more spare time to work on his own ideas. He had built a little model of a heat engine operating with ammonia, the gas used in Linde's refrigerators, but it did not work. Now he turned to heavy oil. Within less than two years (1890–1) his internal combustion engine was completed—that is, on paper. Painful headaches, which his doctor was unable to relieve, made work extremely difficult for him, but he forced himself to complete his task.

His patent was nearly refused because the experts at the Berlin Patents Office failed to see the fundamental difference between this and previous internal-combustion engines. Diesel had made a great step forward in the direction of an "ideal" isothermal prime mover: his engine ignited the fuel (cheap, heavy oil) by compression heat (up to 800°C at 35 atmospheres). The Diesel engine has no sparking plug, and no carburettor; the fuel is injected at the end of the compression stroke in the form of a fine mist, pure air having been drawn into the cylinder on the induction stroke. Combustion is somewhat slower than in the petrol engine, but as the expansion of the gases continues throughout the ignition stroke the pressure, and therefore the temperature, in the cylinder remains almost constant. As a result, the Diesel engine has an efficiency of 30–36% as against the 22–25% of the petrol engine.

Early in 1892 Diesel's patent (No. 67207) was granted, and he described his engine in a little book, *Theorie und Konstruktion eines rationellen Wärmemotors,* which he sent to a number of leading industrial concerns. A year later he signed a "pretty agreement", as he called it, with Krupp's and the *Augsburger Maschinenfabrik.* The first Diesel engine took shape in the latter's workshop. It nearly blew up at the first test; but, working like a madman, Diesel designed, built, rebuilt, and redesigned until in June 1895 the first really satisfactory engine was demonstrated to the engineers, industrialists, scientists, newspaper men, and business people who flocked to the Augsburg works to see the new world wonder. Diesel's fame quickly spread all over Europe.

Yet, amid all his success, difficulties mounted. There were patent suits against Diesel in several countries, and he had to travel from court to court, from lawyer to lawyer. Meanwhile, many of the engines turned out by the Augsburg factory, which lacked his personal supervision, developed faults and customers began to complain; soon he was running into debt. Besides, he had developed an *idée fixe* to which he devoted much unproductive time: he wanted to solve "the world's social problem". No one took this seriously, which was a deeply felt disappointment to him. He tried to tell his wife of his troubles. She did not understand, and he kept it all to himself. He felt the noose of his difficulties growing tighter around his neck.

In September 1913 he visited the international exhibition at Ghent, and had intended to proceed to London. "I don't feel well at all," he wrote to his family. "I'm worried about my heart. Sometimes I feel it might stop altogether." His desperate plan to put an end to his life must have matured during those days at Ghent. The last doubts about Diesel's end were dispersed when the body of a man was fished from the Channel by a Dutch boat. The contents of his pockets, later to be identified by his sons as Diesel's, were retained but the body was returned to the sea.

IS BIOLOGY CHEMISTRY?

MAGNUS PYKE, Ph.D., B.Sc., F.R.I.C., F.R.S.E.

The progress of scientific thought and modern discovery has today put the chemist in a peculiar position. Chemistry is by definition the science of the composition of matter. As long as matter was recognised as being solid stuff made up of a variety of hard, indivisible atoms each with its own fixed atomic weight and each combining and recombining in tidy arithmetical proportions according to Dalton's law, chemists knew where they were. But as soon as Becquerel in 1896 discovered that element 92, uranium, was *not* a permanent substance but was constantly degenerating into something else and—worse still—when in 1905 Einstein showed that there was a mathematical relationship between mass and energy and that the solid *stuffs* the chemists had been accustomed to dealing with were not really there at all but were only a form of elemental energy, chemistry ceased to be a tidy, definable science and began to extend into physics. But whereas chemists were drawn into physics almost against their better judgment, they have agressively marched into the territory of biology. This advance has indeed penetrated so deeply that it is now useful to consider what there is left of biology as an independent science.

THE TERRITORY OF THE BIOLOGIST

Before 1858 the intelligent man's views of biology were in essence derived from the Book of Genesis. You will remember that on the third day of creation God said, "Let the earth bring forth grass, the herb yielding seed and the fruit tree yielding fruit after his kind, whose seed is in itself." And on the fifth day He said, "Let the waters bring forth abundantly the moving creature that hath life, and fowl that may fly above the earth in the open firmament of heaven and . . . great whales and every living creature that moveth." Then it was the turn for "cattle and creeping thing and beasts of the earth after his kind". Last of all came man, "in the image of God created He him; male and female created He them". All these living things are the business of biology, and up to 1858, a short one hundred years ago, it was accepted that biology was quite separate from chemistry. Life was a matter of spontaneous creation, not just one occasion as described in Genesis, Chapter 1, but at any time. Frogs and eels were generated from mud, maggots from bad meat, mice from refuse. Rational men had accepted this hypothesis for generations. Such people as Newton, William Harvey, Descartes and Van Helmont never seriously questioned the matter. And it was also accepted without doubt that organic substances derived from living things were different in kind from those substances open to investigation by chemists. Only "life force" could produce such material.

Today our outlook is quite different. Wöhler and Liebig, following the laboratory synthesis of urea in 1828, and Berthelot, who in 1856 made formic acid, ethylene and from this alcohol (previously regarded as a purely biological product), showed that organic substances were as appropriately a subject for chemical study as inorganic ones. The theory of evolution (that is, the development of more complex biological forms from simpler ones) broke on the world of ideas in 1858 with the publication of Darwin's "Origin of Species". And it was in this same year of the mid-19th century that Pasteur published the first part of his work that was to lead to the abandonment of the theory of spontaneous generation.

DESCRIPTIVE BIOCHEMISTRY

And so we come to biochemistry: the application of chemical principles to biological problems. To my mind biochemists have passed through three distinct phases in the evolution of their branch of science, although there has been a good deal of overlapping. The first phase of biochemistry is as old as organic chemistry itself and covers the investigation of the chemical nature of the substances of which living organisms are composed. Urea, tartaric acid, oxalic acid, uric acid, lactic acid and glucose were all separated as pure compounds before 1800. The composition of fats as compounds of fatty acids and glycerol was worked out by Chevreul by 1826. Emil Fischer cleared up the chemistry of carbohydrates to a remarkable degree between 1884 and 1900. Amino acids had been known to organic chemistry since 1810 and some fifteen had been identified by 1901 when Hopkins and Cole discovered tryptophane, although the constitution and structure of the protein molecule was in a very nebulous state. In 1921 Hopkins made a great stir when he isolated glutathione from yeast, muscle, and liver. And in 1926 vitamin B_1 was isolated in crystalline form by Jansen and Donath, although its existence had been first deduced in 1897.

Today, this aspect of biochemistry has developed to a remarkable degree. Protein is no longer a mysterious product of "life force", the basic protoplasmic material of the cell, chemists know it to be what its physical structure suggests: a rubber-like polymer made up of amino acid monomer units (Fig. 1). Similarly, the natural structural material of living plants, cellulose, has fewer mysteries for the chemist of today than Bakelite. It is hardly stretching the facts too far to imply that in regard to the physical components of living things the chemist is taking over to a large degree from the biologist.

DYNAMIC BIOCHEMISTRY

But side by side with this *descriptive* phase in biochemistry, in which chemical analysis in all its subtle and complex modern ramifications works out the detailed structure of insulin, crystallises and identifies enzymes, measures acetyl choline in nerve tissue, iodine and cobalt concentration (Fig. 2) in cell contents, and the rest—side by side with all this, we have the change in outlook to the present, the *dynamic phase*.

As long ago as 1785 Lavoisier discovered by experiment that about the same amount of energy was released from a unit quantity of matter whether it was burned in the laboratory or metabolised in the body of a man or an animal. His penetrating conclusion was that, "Life is a chemical function." But although the chemical nature of

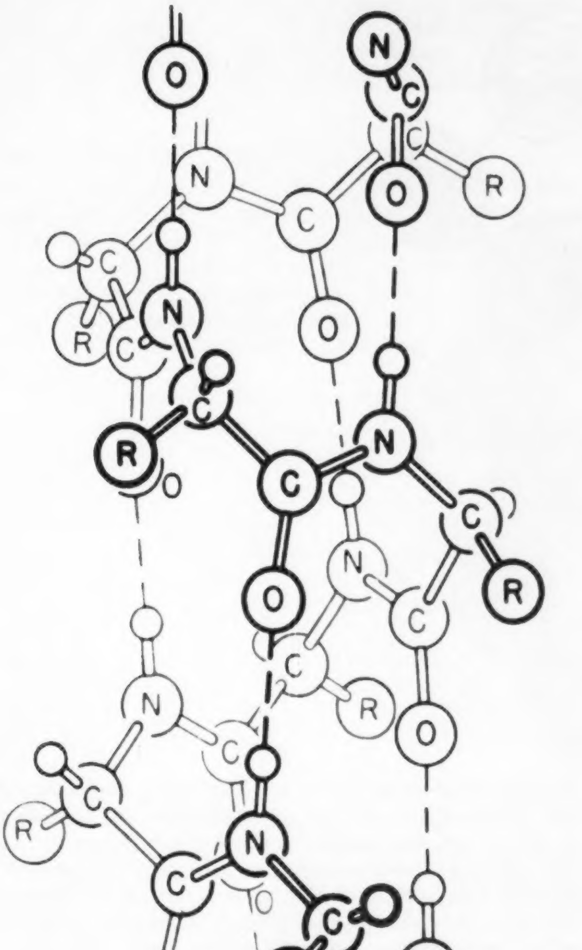


FIG. 1. A protein molecule.

biological energetics has been appreciated with growing clarity for a hundred and fifty years, it was only twenty or so years ago that the chemical mechanisms by which living cells obtained their energy was understood in detail.

Whatever a living cell does has to be paid for in the currency of chemical energy. If there is no free energy available, there is no life. The "life force" of pre-scientific belief has had to be abandoned. The cell, we now understand, knows two methods of getting energy out of the molecules of its foodstuffs: it either fragments them or burns them. The details of how this fragmentation and burning are done have been worked out during the last twenty years. The Embden-Meyerhof-Parnas scheme explains fragmentation and the Krebs cycle one at least of the ways cells burn their fuel. The most recent, and in some respects the most dramatic, advance in chemical understanding to occur during this present *dynamic phase* of biochemistry has been the elucidation of the "hexose-monophosphate cycle". Using the modern techniques of analytical chemistry, and particularly paper chromatography and radioactively labelled molecules, a mass of experimental evidence has begun to fall into shape. A glance at the scheme of operations in Fig. 3 shows that a number of previously unsuspected substances take part. These substances, ribulose-5-phosphate, sedoheptulose, and the rest, and the enzymes that make possible their action and reaction, occur, it seems, not only in living cells like our own which *break down* glucose to get energy, but also in the biological units upon which basically we and the whole of so-called higher living things depend. I refer to leaf cells in which, by photosynthesis, glucose is *built up*.

THE CHEMICAL ORIGIN OF LIFE

Very well, then. As a biologist—if for the moment I can claim to be one—retreating in the face of the triumphant march of chemistry, I will admit that the point first made by Lavoisier, that life is a chemical function, has now been demonstrated in some detail to be true. But there is more to biology than biochemical dynamics. For instance, there is the problem of the hen and the egg, namely, where do living cells come from? Pasteur, to be sure, was a chemist, but he it was who, we all accept, demolished the theory of spontaneous generation. So that even if in passing as a biologist I have to admit that living cells *do* chemical things, yet the cells themselves *are* biological, and are what they are by courtesy of Darwin and his principles of evolution.

Prof. Wald of Harvard University has pointed out that the story of Pasteur's rigorous demonstration of the falsity of the belief in spontaneous generation, his defeat of the naturalist Pouchet before the assembled members of the French Academy of Sciences, is held up to first-year students as a triumph of reason over mysticism. In fact it is very nearly the opposite. The reasonable view was to believe in spontaneous generation for those who found it impossible to accept the idea of a single act of supernatural creation. For this reason many rational scientists a century ago chose to regard the belief in spontaneous generation as a "philosophical necessity". It is a symptom of the philosophical poverty of our time that this necessity is no longer appreciated. In the words of Prof. Wald,

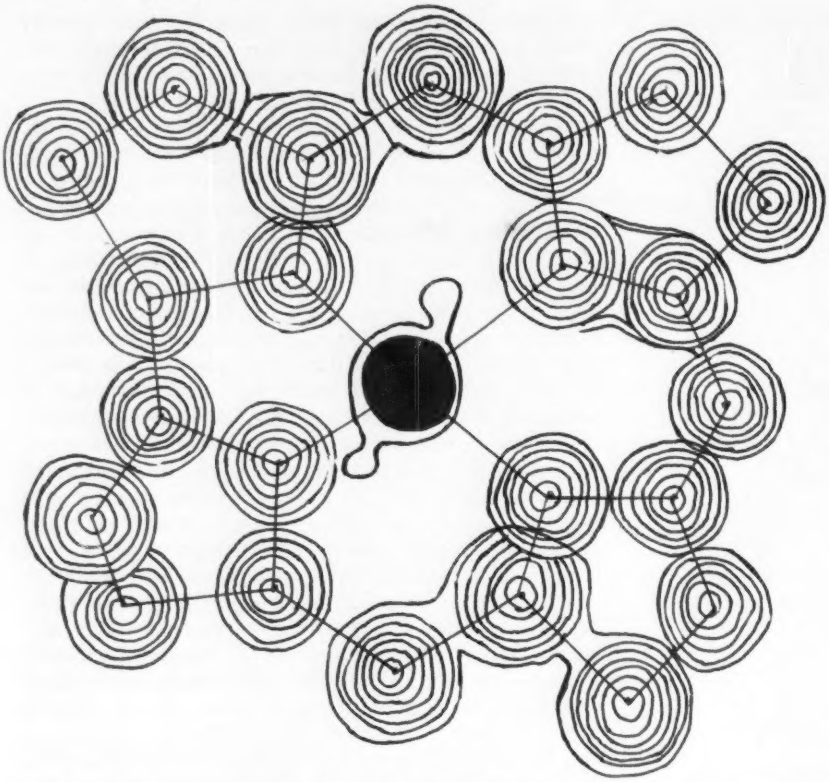


FIG. 2. The molecule of Vitamin B_{12} showing its Cobalt atom (as seen by x-ray crystallography).

"most modern biologists, having reviewed with satisfaction the downfall of the spontaneous generation hypothesis, yet unwilling to accept the alternative belief in special creation, are left with nothing".

SPONTANEOUS GENERATION—NEW STYLE

Chemists, however, are not satisfied with nothing, and they have now filled this philosophical vacuum. S. L. Miller, working in the laboratory of Harold Urey, who won the Nobel Prize for his discovery of heavy hydrogen, carried out the following classical experiment in 1955. He circulated a mixture of water vapour, methane, ammonia, and hydrogen through an apparatus in which they were exposed to a silent electric discharge. All these gases, the modern astronomers tell us, were highly likely to have been present in the atmosphere of the earth before life existed. At the end of a week Miller analysed his solution by paper chromatography and found it to contain glycine and alanine in a mixture of other amino acids. The yield was surprisingly high. Here, then, we have a demonstration that organic materials, and more particularly amino acids, the components of protein (the essential constituent of living organisms), may be produced without the need for any living progenitor. This purely chemical demonstration is now on hand to suggest that spontaneous generation is possible and was indeed likely. I might add that Prof. Oparin, a distinguished member of the U.S.S.R. Academy of Sciences, in the third edition of his great book on the origin of life on the earth, which has just been published, states that this American work has been fully confirmed in Moscow by Pasynskii and Pavloskaya.

It is, perhaps, a far cry from the spontaneous generation of amino acid molecules to the appearance of biological life. The x-ray crystallographers, however, are beginning to tell us that the complex molecules in cells are in fact positioned in a regular spacing and orientation in accordance with the laws of chemistry. It is not too far-fetched, therefore, to conceive that protein molecules, some of which will develop enzyme activity, will have been elaborated from the random amino acids in the primordial sea. Oparin has indeed made the ingenious and plausible suggestion that natural selection, which the biologists accept so readily for the world of the recognisably living, can be pushed right back into chemistry to account for the development and survival of the fittest of the more complex molecules, capable of preying on simpler molecules.

The devout man will notice that the sort of spontaneous generation we have just been postulating could only happen once. Any amino acid produced by modern discharges of lightning will be consumed by existing living creatures long before it can hope to elaborate itself into something new. It is also worth noting that the earliest biological entity, after its spontaneous creation by the sort of random chemical process I have indicated, would need to run its metabolism without atmospheric oxygen, that is, by fermentation. It was necessary for the process of evolution to invent a cell capable of photosynthesis before there was any oxygen in the earth's atmosphere—oxygen being a by-product of photosynthesis. This, then, made two important things possible; firstly, it enabled oxidative glycolysis (that is, respiration) to take place. The chemical effectiveness of respiration is about thirty-five times as effective as that of fermentation, the burning of 180 g. of sugar in respiration yielding 700,000 calories compared

with 20,000 calories produced by fermentation. The second advantage of having oxygen in the atmosphere was to form, as ozone, a screen round the earth to protect living cells from ultra-violet radiations which would otherwise kill them.

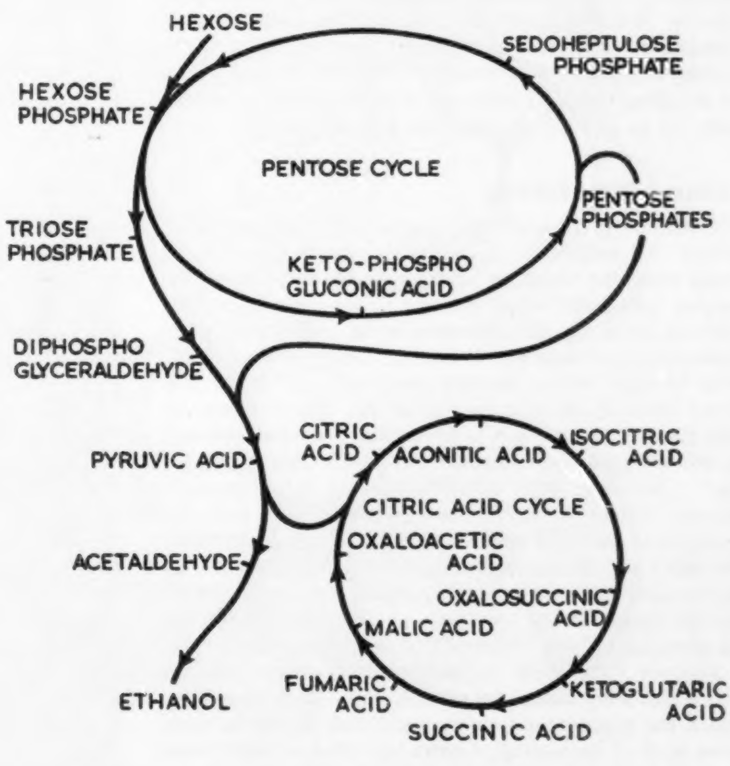
THE CHEMICAL INSTRUCTOR

The most remarkable phenomenon in biology is the single fertilised cell which divides, and divides again, and yet again, and which produces here and there, as the later cells in their turn divide, specialised cells and structures—livers, kidneys, skin, hair, muscles—until at last the full complexity of a fruit fly, or a mouse, or a hedgehog, or a man stands before you. How does the original cell know how to do this?

Part of the answer appears to be a chemical one and to lie in the nature of the particular type of deoxyribonucleic acid present in the cell. This substance, DNA for short, is, so the evidence now accruing would suggest, the component of the chromosomes of the mitotic apparatus which is able to transmit genetic information. DNA can be extracted from cells by mild chemical methods, and much experimental work has been carried out to discover its chemical nature. This work has been conspicuously successful. It is now known that DNA consists of a very long chain made up of alternate deoxyribose sugar units and phosphate. The phosphate and the sugar are regularly linked in the chain, repeating the same phosphate-sugar sequences over and over again (Fig. 5).

But while the phosphate-sugar chain is perfectly regular, the molecule as a whole is not, because each sugar has a "base" attached to it and the "base" is not always the same, two of them are purines, adenine and guanine, and two are pyrimidines, thymine and cystosine. So far as is known the order in which they follow one another along the chain is irregular, and probably varies from one piece of DNA to another. In fact it is suspected that the order of the bases is what confers specificity on a given DNA. Physico-chemical measurement and electron-microscope pictures show that the giant, polymeric molecule of DNA is a long thin one about 20 Å. thick and 30,000 Å. long.

The remarkable structure of the DNA molecule was largely elucidated by Watson and Crick working at the MRC Unit in the Cavendish Laboratory at Cambridge. Using the complex mathematical techniques of X-ray crystallography, they demonstrated with some certainty that DNA consisted of two helical coils, each with more than a thousand twists, and connected like two interlocking corkscrews. And just as messages in the Morse code are indicated by the order of a stream of dots and dashes, so, it is now suggested, is the genetical information of biology transmitted from one cell to the next by the arrangement of groups of purines and pyrimidines in a chemical molecule. If you object that a cell needs to be given a lot of instructions before it can know how to turn itself into a man, it can be pointed out that the total length of DNA in a single chromosome contains about 10 million turns of its corkscrew molecule.



EMBDEN MEYERHOF PARNAS SCHEME

FIG. 3. Biological energy release systems.

THE AWKWARDNESS OF BIOLOGY

Nevertheless, let us consider some of the problems which the biologist still has to deal with in spite of all the information that chemistry can provide to help him.

If small portions are cut out of an embryo in the early stages of its development and are grafted into a second egg in a different position, they will there develop, not into the appropriate part of the second organism, but into an ear, a nose, the lens of an eye, or a nervous system. These excised parts are called "organiser" regions. The experimental embryologist has also discovered that different regions of the cytoplasm of the egg may have specific properties, so that a particular region *can* only develop in one way no matter what is done to it. Such regions are spoken of as "ooplasms". Then again, different parts of an egg or embryo may react with one another in such a way as to change the capacity for development of one (or sometimes both) of the reactants. Processes of this kind usually take place after the period of cleavage when the shiftings and foldings of gastrulation bring together parts of the embryo which were previously separated. This effect is called "evocation". Finally, some biologists think that they can define "individuation fields". These are areas in an embryo within which (and only within which) some special structure, let us say a leg, can be made to develop.

When he begins to study actual embryos, and the way they actually grow, and the peculiar observations which the biologists have been able to record about them, the biochemist soon becomes bewildered. Studies have been made to identify the biochemical processes which play a crucial role in "differentiation", to elucidate the mechanism of "organiser" action and to determine the composition of the mitotic apparatus. And behind it all are the coils and coils of the giant chemical molecule of DNA in the genes that carry, as we presume, the genetical information.

LIVING POLYMERS

Chemistry is the science dealing with the composition of matter. Consequently, it covers the composition of the living creatures found on earth, since we now know that organic substances found in living things are not specially different from organic substances found anywhere else—in laboratories, for instance. It is to that extent in competition with biology, whose territory comprises just those very living forms in all their diverse variety. Biochemistry can also claim in recent years to have made profound advances in understanding the chemical mechanism that makes life "go". We now have detailed backing for Lavoisier's dictum: "*La vie est une fonction chimique.*" We may even have got to the point where we know the simple chemistry by which life started on the earth. Finally, there are the recent remarkable advances in polymer chemistry to show us the extraordinary molecule of DNA, by which the dividing cell is "told" what sort of animal to become.

And yet . . . and yet . . . there are large parts of biology which chemistry cannot yet explain. The simple newt upon which the experimental embryologist has played the well-worn trick of implanting an extra leg—back to front!—can still elude the chemist. Even in the field of polymer science, about which the chemist has become so proud, biology has still something special to teach.

Let me quote a recent saying of Prof. Astbury. "The development of brilliant new chain-molecules like nylon, terylene, and so many others, has within quite short memories almost changed the face of civilisation; but how much more we have still to learn, how much more ingenious and beautiful the fabric of life, of which the meanest thread is purest wonder! . . . The plan which governs the structure of a bacterial flagella, that of a cylinder of nine subfibrils enclosing two others—we owe its recognition to electron microscopists working in many laboratories—is surely one of the master micro-anatomical discoveries of our time. . . . They are single macromolecules —monomolecular muscles, in effect—only about 120 Å. thick, yet in this tiny compass they are complete. They represent the molecular mechanism of biological mobility stripped down to its barest essentials."

Is biology chemistry?

I began by quoting from Genesis. It is therefore only appropriate for me to finish by quoting Exodus. You will remember that Aaron cast down his rod before Pharaoh and before his servants and it became a serpent. And when the rods of the magicians of Egypt also became serpents Aaron's rod swallowed up their rods. But which can more appropriately be equated with biology and which with chemistry it is, I suggest, premature to decide.

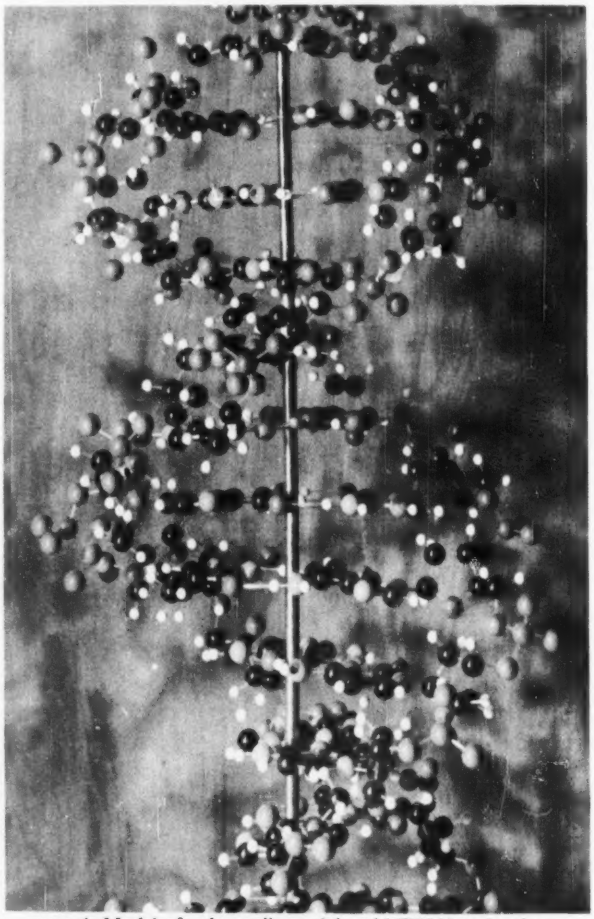


FIG. 4. Model of a deoxyribonucleic acid (DNA) molecule, an exhibit for the United Kingdom Pavilion at the Brussels Exhibition.

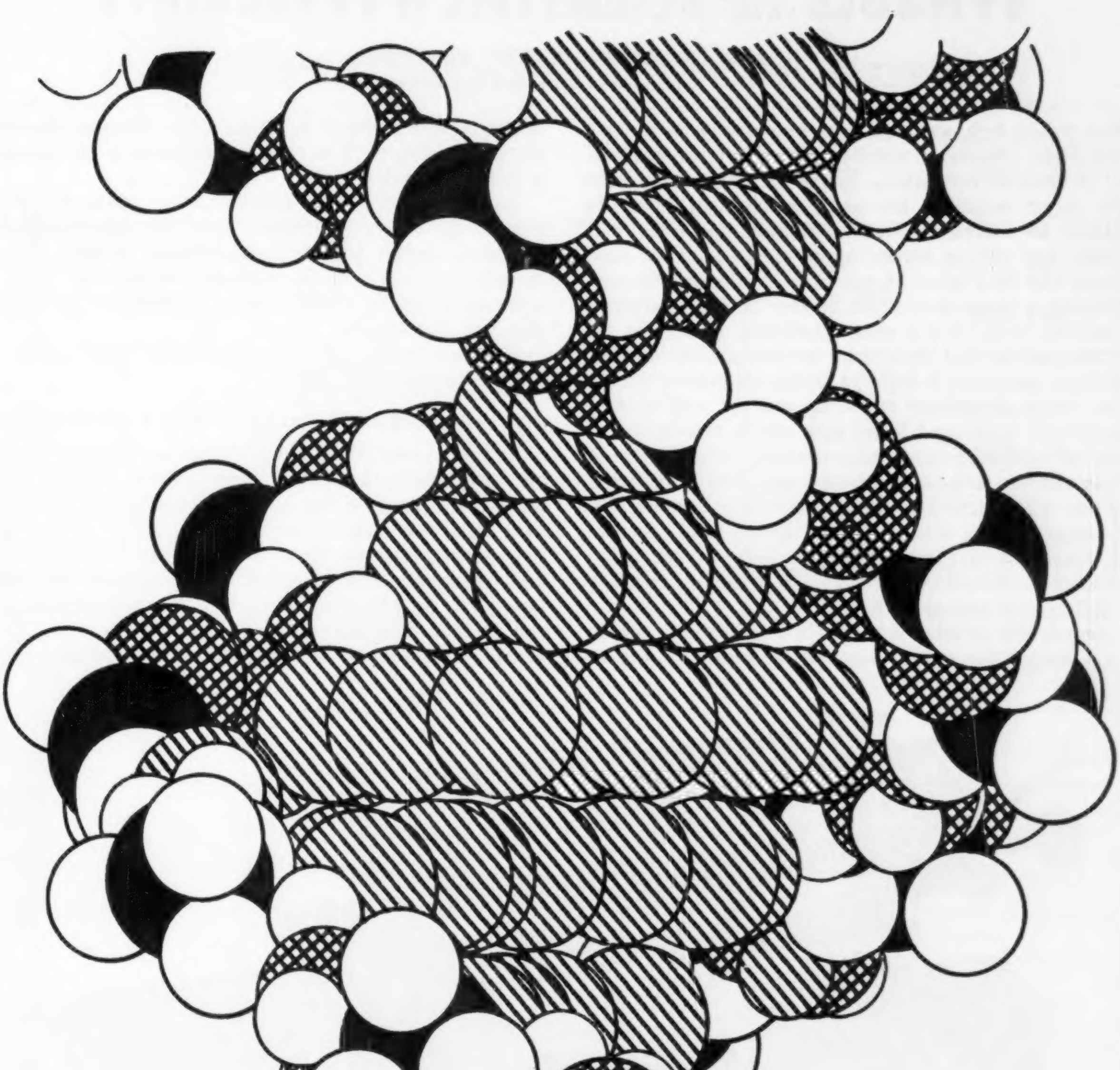


FIG. 5. Deoxyribonucleic acid. The phosphate and sugar are regularly linked in the very long chain in which the phosphate-sugar sequences are repeated over and over again.

SYMBOLS IN SCIENTIFIC TYPESCRIPTS

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When writing technical papers one may often wish to use a fairly large number of mathematical and other symbols, and to establish correlations by the use of the same letter with minor variations for nearly related quantities. In addition to superscripts and subscripts, one often uses upright and sloping letters, upper case and lower case, normal and bold face. Manuscripts are difficult to read; typescript is convenient if the number of copies required is not too large. For a wide circulation, printing is the obvious answer; but even there an intermediate version, usually in typescript, is required for the compositor to work from. With an ordinary typewriter one has only a single alphabet in upper and lower case and a very restricted range of mathematical or other symbols. Blanks may be left in the typescript and subsequently filled in by hand, but this is laborious and suffers particularly from the disadvantage that the separate copies usually need filling in individually so that there is the possibility of differences and errors in the different copies. The individual checking of all the copies adds to the labour.

One possible solution is to obtain a typewriter in which it is arranged that one or more of the key heads can be detached and replaced by others with different symbols embossed on them. The chief disadvantage of this scheme is that it is very slow.

Instead of substituting individual key heads one may remove the whole type basket from the typewriter and substitute another provided with different symbols. This, though more expensive, is reasonably satisfactory. It provides more rapidly a wider variety of symbols, but still is slow and cumbersome.

There are other ways of tackling this problem, and two of these are described below.

I. THE IMPERIAL DUAL-UNIT TYPEWRITER

At the request of the United Kingdom Atomic Energy Authority, the Imperial Typewriter Company Limited have developed equipment that consists essentially of two complete typewriter units mounted side by side but fitted with only a single carriage (Fig. 1). The paper, or papers and carbons, are placed in the carriage in the ordinary way, and typing can proceed as usual on, say, the left-hand unit. A rail extends right across the two units at the rear. The whole carriage with its traverse mechanism can hinge and

FIG. 1. The Imperial Dual-Unit Typewriter.

RUN-OFF OF

IMPERIAL DUAL-UNIT MATHEMATICAL KEYBOARD

1ST UNIT (*Left-hand*)

&	"	/	†	*	_	§	'	(	?	)	‡	**TOP ROW:**	(UPPER CASE)
1	2	3	4	5	6	7	8	9	0	-	·		(LOWER CASE)
Q	W	E	R	T	Y	U	I	O	P	$\frac{1}{8}$		**2ND ROW:**	(UPPER CASE)
q	w	e	r	t	y	u	i	o	p	$\frac{3}{8}$			(LOWER CASE)
A	S	D	F	G	H	J	K	L	:	$\frac{5}{8}$		**3RD ROW:**	(UPPER CASE)
a	s	d	f	g	h	j	k	l	;	$\frac{1}{3}$			(LOWER CASE)
+	Z	X	C	V	B	N	M	,	.	$\frac{7}{8}$		**BOTTOM ROW:**	(UPPER CASE)
=	z	x	c	v	b	n	m	,	.	$\frac{1}{2}$			(LOWER CASE)

2ND UNIT (*Right-hand*)

$\prod$	x	y	z	α	β	γ	m	n	p	≃	$\sum$	**TOP ROW:**	(UPPER CASE)
	1	2	3	4	5	6	7	8	9	0			(LOWER CASE)
Δ	Θ	Λ	Π	Σ	Φ	Ψ	Ω	Γ	$\int$	{		**2ND ROW:**	(UPPER CASE)
δ	θ	λ	π	σ	φ	ψ	ω	γ					(LOWER CASE)
°	′	″	‴	ρ	∇	∞	>	<	→	}		**3RD ROW:**	(UPPER CASE)
α	β	ϵ	ζ	η	κ	χ	μ	ν	±				(LOWER CASE)
~	∝	×	|	≡	≥	$\surd$	(	)	/	·		**BOTTOM ROW:**	(UPPER CASE)
τ	ϖ	ϑ	∂	√	≤					··			(LOWER CASE)

NOTE: Double-length characters are single-case only; they are obtained without having to use the shift-key:- $\prod \; \sum \; \int \; \{ \; \} \; \surd \; (\;) \; /$

"Exponential" characters are grouped on top line of 2nd Unit. Printed normally, they appear in the "suffix" position:- H_2O H_2SO_4

If required in the upper, (or "index") position, platen should be turned back one tooth, which gives this result:- $(a + b)^2$, $2xy^3$, $(x-y)^n$

FIG. 2.

slide on this rail. The carriage can thus be moved by means of a single lever from its normal position above the left-hand unit to a similar position above the right-hand unit. Guides and detents are provided so that the carriage fits without uncertainty into one or other of these positions but is not usable in between. One may type a few letters or a few words on one keyboard, transfer the carriage to the other unit and continue typing without having to worry at all about register, as this is automatically assured.

The use of the dual-unit typewriter thus presents no unfamiliar problems, and operators say that it is easy to get used to it. To move the carriage from one unit to the other takes less than a second, and one operator continually moved the carriage back and forth between the units as the sequence of symbols in the line required. Another operator found that on occasions it was convenient to type all the words of the line on one unit, to transfer the carriage at the end of the line, and to go back on the other unit putting in such symbols as had been omitted.

The dual-unit typewriter is a specialised piece of office equipment, and as it costs about two or three times as much as an ordinary typewriter it is not likely that all offices will be able to justify its purchase. For those offices that undertake a fairly large amount of typing of technical and/or mathematical papers, such a dual-unit machine proves an enormous saving in time and effort. A number of these new machines have already been provided to Government Departments and to industrial firms.

As two complete keyboards are available the number of additional symbols can be large. An ordinary typewriter can accommodate about ninety-two different symbols. With two keyboards there would be space for twice this number. Occasionally, though, it is convenient to use the two possible spaces on any one key head for one large symbol twice as high as normal. The commonest requirement of this sort is for brackets of various kinds. Sometimes too it may be convenient for the integral and summation signs. The dual unit typewriters can be supplied for different sizes but it would seem that pica type is probably the most suitable. A representative selection of letters and symbols is shown in Fig. 2. The choice will depend on the nature of the work to be undertaken. A typical keyboard layout for mathematical work included the Greek alphabet, both lower case and upper case, and a complete range of mathematical symbols. This choice required the exclusion of all common fractions but allowed the provision of a set of numerals 0–9 of half the usual height. These were so placed with respect to the normal that they would act as suffixes to symbols. They could conveniently be used as superscripts or indices if the roller and paper were moved by one notch, which in this case was equal to half a line spacing. Some other half-size symbols were also provided such as l, m, n, x, y, z, and it would have been an advantage to have also i, j, k, for suffixes. Fig. 3 is a reproduction of a few lines of type from this machine.

The quality of the work that can be produced with the dual-unit typewriter is as high as that possible with standard machines, and the rate of typing of straightforward material need not be slower than that with a standard machine as the layout and design of one or other of the two units is so little different from normal.

It is, perhaps, indicative of the extensive requirement for many symbols that one still cannot accommodate all that one wishes on a dual-unit machine. Development work has already begun on triple-unit machines.

II. THE INDICATION OF SYMBOLS ON ANY ORDINARY TYPEWRITER

For offices that undertake a large volume of work, a dual-unit typewriter as described above is obviously a valuable solution. However, for many of us the purchase of specialised equipment is not warranted, and it would be desirable to find some solution to the problem which did not require a special typewriter, but which would allow one to type mathematical work and to distinguish a large number of symbols using any ordinary upright or portable typewriter. A convention used by many printers is to underscore letters that should later be published in *italics*, and to use a wavy underscore to indicate **bold face.**

I would suggest that it might be valuable to agree on a number of simple composite symbols of this sort which would become generally acceptable in typewritten documents and which could be transposed to the more easily distinguishable symbols when letterpress with its wider variety of founts is used. For example, one might use the alphabets:

A	B	–	Z	for ordinary upper case.
a	b	–	z	for ordinary lower case.
$\underline{A}$	$\underline{B}$	–	$\underline{Z}$	for italic upper case.
$\underline{a}$	$\underline{b}$	–	$\underline{z}$	for italic lower case.
A	B	–	Z	for bold face upper case.
a	b	–	z	for bold face lower case.
$\underline{A}$	$\underline{B}$	–	$\underline{Z}$	for italic bold face upper case.
$\underline{a}$	$\underline{b}$	–	$\underline{z}$	for italic bold lower case.
A	B	–	Z	for script figure upper case.
a	b	–	z	for script figure lower case, etc.

As an extension of this idea one might very well fix on a similar set of composite symbols that could be used without the need for lengthy explanations as substitutes for Greek symbols. One could use, say, the solidus superimposed on letters such as a, b, g, d, . . . for alpha, beta, gamma, delta, . . . and could indicate in the same way as above the use of sloping characters by a simple underscore; or bold face by the superposition of a bracket, as above. That is, $\not{a}, \not{b}, \not{g}, \not{d}, \not{e}$, . .; would correspond to $\alpha, \beta, \gamma, \delta, \epsilon$, . .; $\not{D}, \not{G}, \not{P}$, . . to Δ, Γ, Π, . . .; and $\underline{\not{D}}, \underline{\not{G}}, \underline{\not{P}}$, . . to $\mathit{\Delta}, \mathit{\Gamma}, \mathit{\Pi}$, . .

If the suggestions concerning the composite alternatives for the Greek alphabet are in principle accepted, it is desirable that there should be some agreed convention for those letters that have no direct counterpart. Perhaps one might associate c and chi, v and psi, w and omega, q and omicron, h and theta, o and phi. The last pair is suggested mainly because it has long been customary to produce phi in typescript by the superimposition of an o and an oblique stroke.

The pump pressure:-

$$p = \int_0^c \frac{JH}{10}\,dz = \frac{1}{8\pi}\left\{H_0^2 - H_c^2\right\}\ \text{dynes/cm}^2$$

The pump output:-

$$P_0 = \frac{v\ a\ b}{8\pi\ 10^7}\left\{H_o^2 - H_c^2\right\}\ \text{watts}$$

The pump input:-

$$P_I = P_o + \text{ohmic losses in fluid}$$

$$= V\ I\ e^{j\phi}$$

$$= \left|\frac{H_0\ v\ b}{10^8} - \frac{10\rho b}{4\pi}\left(\frac{dH}{dz}\right) = 0\quad ac\bar{J}\ \cos\phi\ \text{watts}\right.$$

The ohmic losses in the fluid:-

$$P_1 + P_{61} = \int_c^0 \rho J^2\ ab\ dz$$

$$= \left(\frac{10}{4\pi}\right)^2 \rho a\ b \int_0^c \left(\frac{dH}{dz}\right)^2 dz\ \text{watts}$$

FIG. 3. A typical specimen of the class of work which can be produced on the Imperial Dual-Unit Typewriter.

I have tried these ideas out on occasions and have found that it was easier to get a manuscript typed with these composite symbols than to arrange that adequate gaps were left in the typescript for the insertion of handwritten characters. The typescript, too, was more easily legible, and there were fewer reading errors and proof corrections required when print was set from this typescript.

If one is not proposing to use Greek letters, one might use these composite symbols, with the oblique stroke through the letters, merely as an additional alphabet.

There is one other aspect of this problem. It may be inconvenient and clumsy when dictating matter that will use these composite symbols to have to say every few moments " 'a' with an oblique stroke through it". Proof-reading particularly can be speeded up if one uses a consistently produced set of names for these composite symbols. Such a set can be easily devised, for example, by adding a consonant such as a "t" or the sound of "ate" following the sound used for each letter of the alphabet, so that $\cancel{a}, \cancel{b}, \cancel{c}$, . . . are pronounced "ate", "bate", "cate". . . .

The symbols and sounds suggested above are easily distinguishable from one another. It is easy to ensure that deletions are recognisable as such if an X is superimposed on a symbol to cross it out. There are other advantages in the use of composite symbols such as those suggested, as compared with the use of a' , a'' , a''', . . The composite symbols take up less space. They are less confusing, particularly when it is necessary to indicate raising to a power. (That is, $\cancel{b}^2$ is more legible than b''^2.)

It would be convenient, too, to standardise on a number of composite symbols to be taken as the identical equivalents of the more usual mathematical symbols. For example one might use:

$\overset{S}{S}$	for	$\int$	the integral sign
$\frac{\cancel{d}x}{\cancel{d}y}$	for	$\frac{\delta x}{\delta y}$	
$\frac{\mathrm{d}x}{\mathrm{d}y}$	for	$\frac{\partial x}{\partial y}$	
$\frac{d\underline{x}}{d\underline{y}}$	for	$\frac{dx}{dy}$	
$)\cancel{a}($	for	$\lvert\alpha\rvert$	modulus of alpha
$\llcorner\ \lrcorner$	for	[ ]	square brackets
( )	for	**( )**	bold brackets
$\leftarrow\ \rightarrow$	for	**[ ]**	bold square brackets
$\Leftarrow\ \Rightarrow$	for	{ }	curly brackets

7	for	>	greater than
7 7	for	$\gg$	much greater than
$\angle$	for	<	less than
$\angle\angle$	for	$\ll$	much less than
$\not 7$	for	$\not>$	not greater than
$\bar{\bar{7}}$	for	$\geqslant$ $\geq$	greater than or equal to
$\underline{\underline{u}}$	for	≒ ≏ ≃	approximately equal to
$\underline{!}$	for	$\perp$	perpendicular to
//	for	$\parallel$	parallel to
--)	for	$\rightarrow$	tends to, or yields
(--	for	$\leftarrow$	yields (in reverse direction)
$\overset{\text{I}}{\text{V}}$	for	$\downarrow$	decreasing, or decreases with
$\overset{\text{A}}{\text{I}}$	for	$\uparrow$	increasing, or increases with
OO	for	∞	infinity
OC	for	$\propto$	varies as
o-o	for	$\sim$	the difference between

It is clear that there are a large number of other symbols that have not been discussed above. It is not supposed that the suggestions made here form a complete or exhaustive list. I should be grateful if further suggestions for other commonly used symbols could be sent to me. I would also be glad to receive comments about the likelihood of confusion or ambiguity in specific cases with any of the composite symbols illustrated.

It would be possible as a refinement if these ideas were accepted to fit on a typewriter keyboard separate keys for the additions to be made to letters to give the composite symbols, and to arrange that these were dead keys similar in operation to those that are used for accents in French. This would largely avoid the use of the backspace key. In such a case it would be possible to design indicators that would be even less easily confused than those suggested above. Those above, however, do have the great advantage that they can all be produced on any unmodified typewriter.

TWENTY-FIVE YEARS AGO

THE PROGRESS OF THE "POLAR YEAR"

"In the Arctic regions the past year has seen the inauguration of a remarkable effort in international co-operation. The 'Polar Year' has now been in progress for some months . . . the following extracts deal with research which is of general interest" (DISCOVERY, *1933, vol. 14, No. 159, p. 87). We feel that the research work done at that time is of even greater interest now because of its contribution to the success of the current International Geophysical Year.*

"The Polar Year for the investigation of meteorology and allied sciences in the Arctic has run half its course. In spite of the universal financial stringency and the consequent slenderness of official resources, an imposing number of expeditions is now at work . . . The British Expedition, which is spending a year at Fort Rae on the Great Slave Lake, provides an example of the routine which most of the Polar Year stations will probably follow. On arrival . . . they at once set up the station. Several log-huts were available, both for living accommodation and scientific purposes, though much had to be done . . . before they [were] actually ready for use.

"At first the party experienced uncomfortably high temperatures but later news tells of a steady fall in temperature . . . Fort Rae is one of the coldest places in the world, and 100–110 degrees of frost may be experienced in the winter. It had . . . been hoped that a dog team . . . might be purchased at Fort Rae, but . . . it was found that suitable dogs were not easily obtained. A journey was therefore made by motor-boat to Fort Resolution on the south side of the lake, a somewhat dangerous undertaking owing to the severe storms encountered both on the way there and on the return."

STUDYING AURORAL DISPLAYS

During the early days of the expedition the "attention of the party was concentrated chiefly on the auroral displays [which] are photographed simultaneously [from two research stations], and observed from 11 p.m. to 3 a.m. every night. A routine has been evolved . . . by which the control photographer at the main base has a local telephone line into the near-by hut. A couple of transformers (borrowed from the wireless receiving sets) are used in the telephone line, and the microphone is arranged to actuate two telephones, one for the [technician who records] all the details sent in, the other for a third man in charge of the transmitting set; the latter repeats immediately into the transmitter microphone all the instructions for exposure plates, and ensures during every short lull that all is going well at the other end of the base. The other two of the five men engaged in this procedure are at the sub-station at Old Fort Rae, the one manipulating the camera, the other inside the hut attending to the receiver and transmitter. Other work at Fort Rae includes pilot balloon ascents, meteorological observations, investigations of terrestrial magnetism, and observations in atmospheric electricity.

AN IMPORTANT DISCOVERY

"An important result of the expedition was the finding of about 5000 fossils of lepidosirens and sclerodermi in Franz Josef fjord, a discovery which may be of great value in providing the necessary link between two stages in evolution. The fossils were discovered in a bay where some catastrophe, killing the animals in vast numbers, had apparently occurred in prehistoric times."

(*Photograph by W. H. Steavenson.*)

FIG. 1. The brightest portion of the Milky Way. The galactic equator runs diagonally across the picture, with longitude 310° at the top right and 360° at the bottom left. The arrows in the margin indicate the position of the galactic centre.

RECENT RESEARCH ON THE MILKY WAY

E. A. BEET, B.Sc., F.R.A.S.

In DISCOVERY for August 1950 there appeared an account of the Milky Way and its meaning.* Progress in astronomy is such that although that work is not seriously invalidated, it is far from complete, and the present purpose is to take up the story where it was then laid down. The conclusions then reached can be summarised as follows: The galaxy is a disc-like volume of space of such size that light takes about 100,000 years, or probably a little less, to travel from one side of it to the other. It contains many millions of stars, together with dust and gas which in some places is luminous but in general is an obstruction (like earthly mists) to the passage of light. In the centre the disc is bulged to about one-fifth of its diameter, and out near the edge the Sun is situated. To observers like ourselves the nearer and apparently brighter stars are scattered at random over our sky, but the more numerous, more distant, and apparently fainter stars are confined to the plane of the disc and give rise to the silvery band that we call the Milky Way.

As the Sun is situated near the edge of the system there will be one direction, towards the centre, where there will be far more stars to see and where the Milky Way should be at its brightest. Fig. 1 is a photograph of this region, and here the star-fields are at their widest and brightest. Nevertheless, the brightening is less than we should expect. In the photograph, obscuring clouds can be seen, and in Fig. 2 it will be noticed that except in one spot the central plane is occupied by a dark lane all the way from longitude 285° to longitude 50°, for the obscuring matter lies most heavily in the central plane.

THE INVISIBLE MILKY WAY

When light of mixed colours (of different wave-lengths or frequencies) is passed through a prism and so divided into its constituents, a band of colour is produced, the spectrum. Electromagnetic waves are not, however, limited to those wave-lengths to which the eye is sensitive, approximately

* "What is the Milky Way?" E. A. Beet; DISCOVERY, 1950, vol. 11, No. 8.

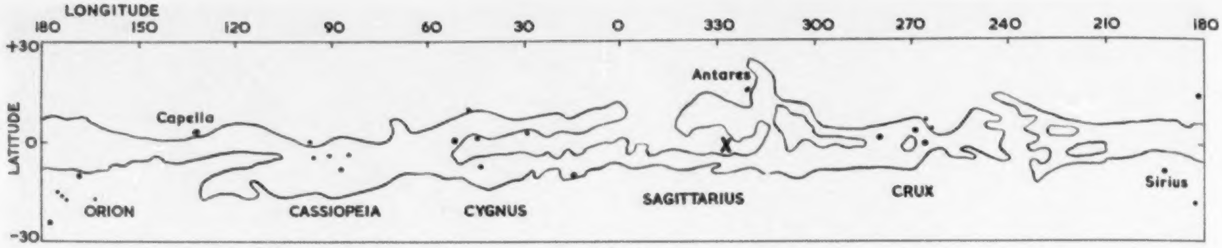


FIG. 2

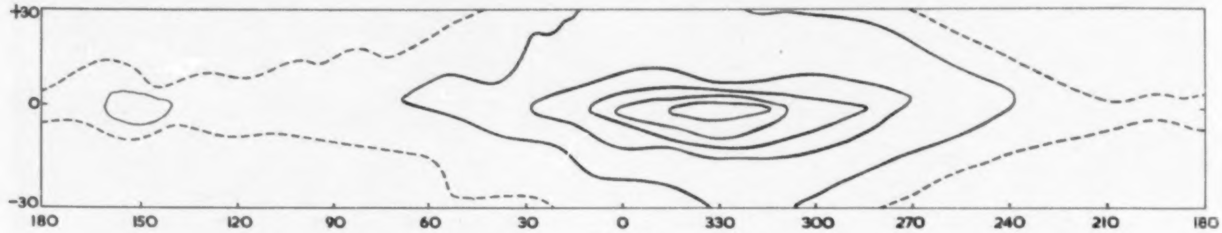


FIG. 3

FIG. 2. (*Upper*): The visible Milky Way. The brightest portion is in the region of the galactic centre, marked *X*, and is shown in Fig. 1. Coordinates are galactic, using the central plane of the Milky Way as the principal axis. FIG. 3. (*Lower*): The invisible Milky Way. A composite drawing from several sources showing how the strength of radio waves received from space increases towards the plane of the Milky Way, and particularly towards the galactic centre. The line of lowest intensity (broken line) is a quarter of an interval below the next one; otherwise the lines repesent equal intervals in radio strength.

from 0·00004 to 0·00007 cm. On the shorter, or blue, side there are ultra-violet, X-rays, and γ-rays as from the radioactive elements. On the long side we have infra-red, short waves as used in radar, and long ones used in broadcasting. The Earth's atmosphere behaves as a selective filter of radiation; it transmits the visible wave-lengths, but not far outside this region it becomes opaque. If an external object emits visible wave-lengths, or closely adjacent photographic ones, we can detect it by optical means, but if its emission is outside this region we cannot detect it at all. Fortunately, in the long waves, approximately from 1 cm. to 20 m., the atmosphere is transparent again, and this band is sometimes called the "radio window". Here we have another means of detecting external objects, and the method of using it can be found in back numbers of this publication.* Some radiation comes to us from outside the galaxy altogether, and some from strong localised sources, but it is the general radiation from the whole sky that concerns us here. Fig. 3 shows the "isophotes", or lines of equal intensity, for the same area of sky as Fig. 2; it is clear that the intensity increases towards the plane of the Milky Way and particularly in the direction of the galactic centre, *X* in Fig. 2, but that is not all. Applications of infra-red photography have shown that longer waves can penetrate dust and other absorbing matter better than short, and it applies here too, as radio waves are but little affected by the interstellar matter that obscures so much of the visible Milky Way. Optically the region of the galactic centre is detectably brighter, but in the radio map it is strikingly so, and the latter also suggests the existence of the central bulge to which reference has been made. In short, the radio method of astronomical research gives us a much better idea of the distribution of matter in the galaxy than does the optical one. Fig. 3 is based on results obtained in Cambridge and in Australia, as neither group of workers can study the whole of the galactic plane, and applies to wave-lengths between 3 and 4 m.

* DISCOVERY, 1953, vol. 14, No. 9, p. 282; 1954, vol. 15, No. 4, p. 185; 1956, vol. 17, No. 8, p. 312; 1957, vol. 18, No. 8, p. 319.

COMPARISON WITH OTHER GALAXIES

In the constellation of Andromeda there is a hazy spot just visible to the naked eye, known as Nebula M31 or as "the Nebula in Andromeda". This is not a part of our galaxy, but is itself a galaxy, situated about 1½ million light years away. There are millions of these "other galaxies", but this example, being one of the nearest and one of the largest, is the best known. Photographs of it have appeared in this journal on a number of occasions,* and show an oblique view of a circular disc-like object such as our galaxy might appear if viewed from outer space. This "sister galaxy" was for many years regarded as considerably smaller than ours, then as a twin, and in fact is probably a little larger. Further examination of the photographs will show that there is a diffuse central nucleus circling around which there are several spiral arms; a similar object, viewed from a direction perpendicular to its plane, is shown in Fig. 6. The outer parts of M31 were resolved into stars many years ago, almost as soon as the 100-inch telescope was brought into use, but it was more recently, in the late war years, that resolution in the nucleus was achieved by the American observer, W. Baade, who has been able to follow up this work with the 200-inch telescope. Into what kinds of stars has it been resolved? To answer this question we must digress for a moment to explain what "what kind" means.

If the spectrum of sunlight be produced with a delicate instrument, the spectroscope, instead of with a simple prism, it is found to be crossed by numerous fine black lines, the Fraunhofer lines. The same applies to the spectra of the stars, but whereas some show an arrangement of lines similar to those due to the Sun, others are quite

* DISCOVERY, 1950, vol. 11, No. 8; 1954, vol. 15, No. 1.

different. On this basis the stars have been classified: for example, classes B and O are very hot stars (20,000–40,000° on the absolute scale) and are blue in colour; the Sun is much cooler in class G; class M are the very cool stars (about 3000°) and are red in colour. The various classes can be identified by photographing their spectral lines, or by using colour filters—a yellow filter and an appropriate film will draw attention to red stars and blue ones will appear quite faint. Both methods of identification are used.

The examination of the Andromeda nebula showed that whereas the bright stars in the spiral arms were predominantly blue, those of the nucleus were red. A neighbouring object was also examined and was found to contain the red stars only, and this one had no spiral arms. Baade called the blue stars Population I and the red Population II, though many other types of object have since been classified as I or II, and some workers prefer more divisions, as many as five, in fact. Sticking to the original divisions, it can be stated that Population I applies to spiral arms, where, incidentally, there are absorbing dust-clouds, and Population II applies to nuclei and to galaxies without spiral arms—dust being absent in both cases. In our own galaxy the neighbourhood of the Sun is particularly well provided with Population I stars and dust-clouds; can it be that it lies in a spiral arm? A survey of Population II stars in our own system, though made difficult in the central regions, as already pointed out, provides evidence for the existence of the central bulge. Thus it seems that the two objects, the Galaxy and M31, have much in common, and we must now consider what recent work has done to reveal the spiral structure of the former.

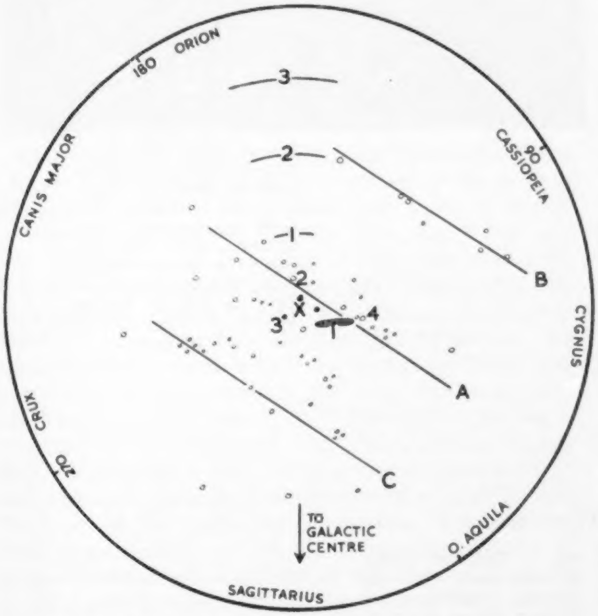


FIG. 4. Spiral arms near the Sun. The numbered arcs are distances from the Sun in thousands of parsecs (1 parsec=3·26 light years or $19{\cdot}2\times10^{12}$ miles). The diagram shows how the clouds of ionised hydrogen tend to lie in three lanes; dark spots are absorbing clouds. *A*, Orion arm; *B*, Perseus arm; *C*, Sagittarius arm; 1, the dark rift in Cygnus; 2, nebulosity in Orion; 3, the "coal sack" in Crux; 4, the "North America" nebula near α Cygni.

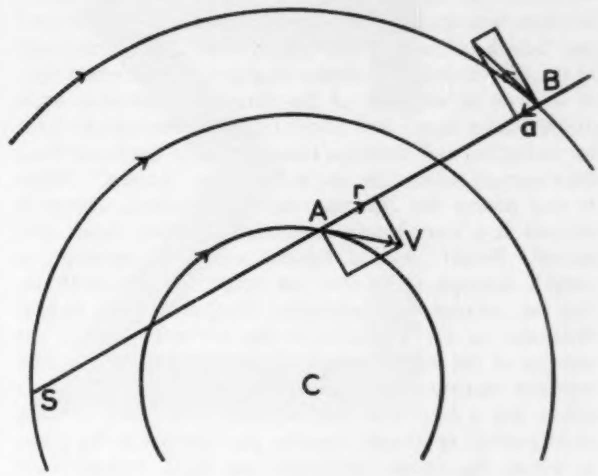


FIG. 5. Line-of-sight velocities due to galactic rotation. An object at *A* is moving faster than the Sun and appears to us to be receding with a velocity *r*; *B* is moving more slowly than the Sun and appears to be approaching us with a velocity *a*.

THE EVIDENCE OF THE HOT BLUE STARS

Let us consider further the evidence of the hot blue stars. Stars are classified in various ways, that already referred to as Population I and II being based on location rather than on individual characteristics. Among these various classes is one called "the main sequence", where, to within reasonable limits, stars of the same spectral type (or colour or temperature) have the same intrinsic brightness. The Sun belongs to the main sequence; it is just an average star; some of its fellows are brighter and some less bright, but they are all comparable in mass and diameter. When the spectral type and apparent brightness of a star have been determined, the former enables the real brightness to be calculated, and when this is compared with the apparent brightness the distance can be estimated. If the star does not belong to the main sequence and the fact has not been recognised, the astronomer will be unlucky, but the chance of this mistake occurring is low enough to make this method a very useful one for distance-determination. W. W. Morgan of the Yerkes Observatory in the United States organised a survey of the blue stars in the Milky Way region, that is, in the plane of the galaxy. In this region, of course, magnitudes of the stars are affected by the interstellar obscuring-matter, but it is possible to make a correction for this and so obtain reasonably accurate distances. He and his collaborators found that these stars, which we believe to be associated with spiral arms, are not distributed at random but occur, individually or in groups, in three distinct lanes. One such lane just includes the Sun but lies mainly farther out from the galactic centre. It has since been called the "Orion arm", though objects belonging to it stretch approximately from longitude 40° to longitude 220°. Another is farther out, the "Perseus arm". The third is rather nearer the galactic centre; its members are found in longitudes 240° to 330°, and it has been called the "Sagittarius arm".

This investigation has been made in another way, again

organised by Morgan but with different collaborators. Mention was made in the opening paragraph of dust and gas "which in some places is luminous". The luminosity of the dust is due to scattered starlight; the gas emits light of its own as an effect of the ultra-violet radiation from neighbouring stars. The atoms of gas receive energy from the radiation, and electrons therein become displaced from their normal orbits—the gas is said to be "ionised". When in due course the electrons return to normal, energy is emitted at a wave-length characteristic of the atoms concerned. Bright gaseous nebulae are quite common, a notable example being that just below the belt of Orion, but the nebulae that interested Morgan are not bright. Hydrogen is very plentiful in the universe, and in the vicinity of the hot blue stars it should be ionised. The resulting emission is a dim red (Hα light) and difficult to detect, but a filter has been devised which, with suitable photographic emulsions, enables photographs to be taken in which the ionised hydrogen (or "H II regions") are brought out in contrast with their surroundings. Baade had discovered such regions in the spiral arms of the Andromeda nebula, and now this team found them in the Milky Way. In 1952 the results were exhibited in the form of a map of the galactic plane with balls of cotton-wool representing these hydrogen nebulae. Fig. 4 is based on this map, with additions from other sources, and shows the three spiral arms as indicated by the hot blue stars and the associated hydrogen emission nebulae. Only a small region of the galaxy is covered by it, but it is a good start. The three lanes increase in distance from the centre in the anti-clockwise direction as in the nebula in Fig. 6, and as the galaxy rotates clockwise (when viewed from the northern side) it must do so with the arms trailing.

THE EVIDENCE OF THE 21-CM. LINE

When a hydrogen atom is not ionised its electron is at its lowest level and no radiation will be emitted. As it happens, there are two possible "ground states" for the hydrogen atom, and if a change should take place from one to the other, there will be a small emission of energy. The wave-length at which it will be emitted is inversely proportional to the energy, and since the latter is small the former will be long by optical standards; it is 21 cm. and hence able to reach us through the radio window. Such transitions are extremely rare, but on the other hand hydrogen

FIG. 6. An external galaxy viewed from a direction perpendicular to its plane. Note the unresolved nucleus and the spiral arms spreading out from the centre in an anti-clockwise direction. Nebula M74 in Pisces. *Mount Wilson Observatory photograph.*

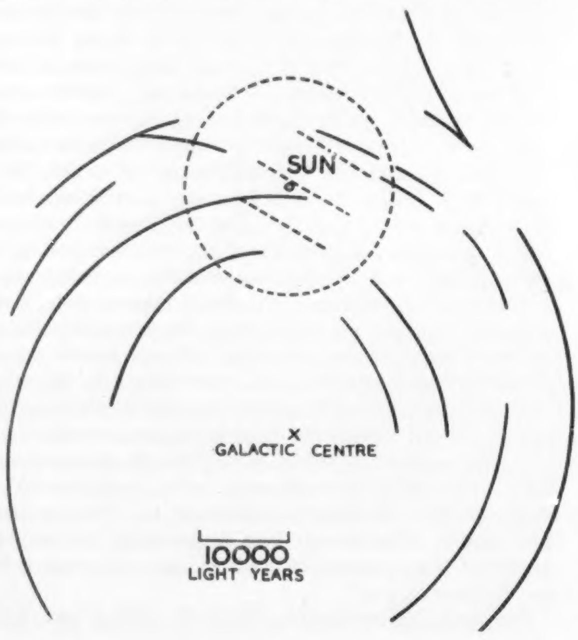


FIG. 7. Our own galaxy as delineated by the 21 cm. radiation. The diagram shows the position, but not the thickness, of the lanes of neutral hydrogen detected by radio methods. Compare with Fig. 6. Fig. 4, reduced to the same scale, is superimposed in dotted lines.

atoms are extremely plentiful, there being more hydrogen in the universe than anything else. Van de Hulst in 1944 suggested that it should be possible, with suitable receivers, to detect this 21 cm. radiation, and in 1951 radio astronomers in Holland, Australia, and the U.S.A. were successful in this experiment. As one expects, the intensity of this radiation increases towards the Milky Way region, for it is in the plane of the galaxy that these clouds of cool neutral hydrogen (the "H I regions") mainly occur. It was found that in general the peak of intensity over a range of wave-lengths was not exactly 21 cm.; it was sometimes a little above, sometimes a little below, and the differences were clearly related with galactic longitude.

It was pointed out in the former article that the galaxy is in rotation, not as a wheel, but like the solar system, objects nearer the centre having larger orbital velocities than those farther out. Consider Fig. 5: *S* is the Sun, *C* the galactic centre, and *SB* a direction in space in which observations are being made. Imagine the Sun to be at rest: then an H I region at *A* would have a velocity relative to the Sun represented by the arrow *AV*. By the parallelogram of velocities, this can be resolved into two components, one of which is a velocity of recession represented by *r*. This will have a Doppler effect upon the radiation received from it. The sound of the engine of a receding aeroplane is lower in pitch than it should be because the motion of the source causes an increase in the length of the sound-waves received by the observer; similarly, the radio waves from A will be rather longer than 21 cm. The cloud at B is farther from the galactic centre than is the Sun, and its relative motion is in the opposite direction compared with that of A. When this velocity is resolved we get a small line of sight velocity towards the Sun, a velocity of approach which shortens the wave-length of the 21-cm. line. Thus the wave-length received from a given direction in space is linked with the distance of the source, enabling the H I clouds to be inserted in distance as well as direction on a map of the galactic plane.

Such a map was exhibited by Van de Hulst in his Halley Lecture in 1953, when he gave an account of the work of the Dutch observers. It showed that lanes of neutral hydrogen coincided satisfactorily with the Orion and Perseus spiral arms. We have already seen that radio methods have a longer reach than optical ones, and in this early map the Perseus arm and the next outside it jointly extended to nearly half a circumference of the galaxy. This map did not, of course, include that part of the Milky Way not observable from Holland, but since then more work has been done by teams in both hemispheres and more spiral arms have been traced. Fig. 7 is based on a diagram by F. J. Kerr given in Bok's *Milky Way*, published in 1957,* and shows how much has been discovered since 1950. It is the result of the patient piecing-together of information from many sources, and of the painstaking research of teams of scientists in a number of countries—each contributing a part to a picture of which the final form is only just beginning to emerge. It is, in fact, a notable example of what Sir Edward Appleton has called "Science for its own sake".†

* An even more recent and more elaborate map by Kerr and others was published in *Nature* for October 5, 1957, vol. 180, p. 677.

† DISCOVERY, 1953, vol. 14, No. 9.

THE PROTECTION OF CROPS

G. C. PROCTER
Plant Protection Ltd, Fernhurst, Surrey

From earliest times it has been realised that whenever man cultivates the soil his crops are reduced by pests and diseases and by the competition from weeds for light, air, and water. Virgil in his poetical treatise on Italian farming refers to primitive seed dressings and to the wild oat problem. It is only in comparatively recent times, however, that the problem of crop protection has been recognised as an international one and that attempts have been made to estimate the effect of the losses. Where figures are reliably calculated the results are staggering. For example, it is stated that something approaching 7000 different species of insects attack crops at some stage somewhere in the world. In the United States, where much time has been spent in studying the problem, it has been calculated that boll weevil and other insects reduce the yield of cotton by nearly 15%. The value of the loss of this crop alone is 334 million dollars a year. The figures for the losses from weed competition are astronomical. The U.S. Department of Agriculture estimate that on fifty-eight crops it reaches a total of 1700 million dollars.

To take examples from the British Commonwealth: 27% of the maize crop in South Africa goes to feed insect pests; the loss of cereals in Australia due to disease alone is worth £27 million sterling a year. In Great Britain, where agriculture may be said to be highly developed, the total losses amount to something like 10%. The average throughout the world is probably nearer to 20%.

Probably the first clear action leading to inter-government collaboration for plant protection was the signing of the Phylloxera Convention in Europe in 1881. Some twenty years previously the vine phylloxera had been introduced from stock imported from the U.S.A. and had become widely distributed in Central Europe and as far east as the Black Sea. Much thought was given to preventing the spread of this and other pests of the grape by quarantine regulations and the proposals reached a final and official status in the Phylloxera Convention.

More recently, an international meeting held under the auspices of the International Institute of Agriculture in 1929 adopted a draft "Convention Internationale pour la Protection des Vegetaux". This was signed by twenty-six countries and remained in force until 1951.

Today international action in the crop protection field is in the hands of the Food and Agriculture Organisation of the United Nations. A number of regional agreements have been signed and technical advice and service has been provided in a number of cases. One of the best examples is the Desert Locust Control which operates anti-locust measures in those countries throughout Africa and the Middle East which are not easily able to organise their own measures.

Scientific organisations and individual experts are generally anxious to pool the benefit of their experience. The success of such meetings as the Plant Protection Inter-

"Agroxone" 4 for the control of charlock in oats—Var. S147 (spring sown). No treatment was given in the foreground; in the background, "Agroxone" 4 was applied at varying rates and times with good results.

national Conference, attended in 1956 at Fernhurst by representatives from forty-two countries, is a measure of this desire for world-wide action.

MEANS OF CROP PROTECTION

Let us now consider some of the new developments in crop protection science. One should say definitely at the outset that chemical treatments are an adjunct to good husbandry. The first essential in raising the level of production is to make the fullest use of improved cultural methods and fertilisers to obtain a potentially healthy plant. Much also has been and is being done to produce disease-resistant varieties of many plants, but this ideal is very far from being reached. In the meantime chemical preventive measures are essential in many cases. We will consider these measures under two main headings: first the chemicals used, and second the means of applying them.

CHEMICALS USED

The chemicals used for crop protection purposes may be divided into three groups: insecticides, fungicides, and weedkillers.

Before the 1939–45 War we had relatively few and relatively simple chemicals to cope with the problems. Among insecticides we had the natural plant products—nicotine from tobacco, rotenone from derris, and pyrethrum powders and extracts—to use as contact insecticides; that is, chemicals which kill when the insects and eggs come in contact with them, either directly or after application to the host plants. Tar oil and petroleum washes were and still are used as contact insecticides. Petroleum oil emulsions used against citrus scale insects are also contact insecticides.

As stomach insecticides we had lead, calcium, and other arsenates, Paris Green, the silicofluorides and, in some of its applications, derris. These products were sprayed or dusted on to the host plant and were ingested with the insects' natural food. Poison baits for killing locusts or cutworms are a special case for the use of stomach insecticides.

Finally, we had fumigants such as hydrogen cyanide and tetrachlorethane. We had no practical systemic insecticides at that time.

Before 1939 we had relatively only a few fungicide chemicals. They were mainly preparations of sulphur and copper for spraying and dusting and, as fungicidal seed dressings, the organo-mercurial products.

Weedkillers too were not very extensively developed. The chlorates, arsenicals, borates, and coal tar products were available as "total" weedkillers. The "selective" weedkillers were few and, apart from sulphuric acid and dinitro-orthocresol (DNC) which are unpleasant and dangerous to handle, they were not used very extensively.

SYNTHETIC INSECTICIDES

The era of the modern synthetic insecticides really began with the discovery in Switzerland early in the 1939–45 War of DDT, which is both a stomach and a contact insecticide and a safe, efficient chemical, effective against a wide range of pests including flies, caterpillars, capsids, and some species of aphids.

There followed almost simultaneously in France and in England the discovery of the insecticidal properties of BHC, which kills much the same range of insects as DDT, with one very important addition, wireworm. BHC was the first economic chemical to be used effectively against this pest. It is generally a better aphid killer that DDT.

BHC has a disadvantage in that it taints certain susceptible crops such as potatoes, but with the purified gamma BHC or lindane, the risk of taint is much reduced. It is sometimes erroneously stated that gamma BHC does not cause taint; the facts are as follows. Crude BHC is a mixture of several isomers which are all capable of causing taint. The highly insecticidal part, however, is the gamma isomer, which forms only about 13% of crude BHC. Therefore, when gamma BHC is used, much less chemical is needed to kill the pest and to this extent it is less likely to cause taint.

To the DDT, BHC range of chemicals have now been added such chemicals as aldrin, dieldrin, and endrin, discovered in the U.S.A. All of them are complex chlorinated compounds. It is not yet known to what extent they will eventually supplant DDT and BHC. Aldrin and dieldrin are both wireworm killers, though less efficient than BHC. The risk of taint is less, and dieldrin in particular is very persistent. Both are relatively more toxic than DDT or BHC, concentrated aldrin especially being easily absorbed through the skin.

The main limitation of all these chemicals is that they do not kill red spider, which is one of the main pests of fruit. Therein lies one of the chief advantages of the phosphorous insecticide parathion discovered by Schrader in Germany during the 1939–45 War. In the course of this work Schrader also discovered a range of phosphorous insecticides having a systemic action and the first of these to be marketed is known by the coined name Schradan. Systemic insecticides are absorbed by the cell sap and carried about the plant so that complete coverage with spray is not so essential as with a non-systemic to render the plant toxic to the insects. They may be applied as sprays or even to the roots as watering treatments. Systemics are effective mainly against aphids and red spider which suck the plant sap. The disadvantage of all phosphorous insecticides is that they are highly poisonous to human beings, and protective clothing must generally be worn when applying them. However, with a recently introduced systemic, Metasystox (demeton-methyl) protective clothing is required only when mixing the concentrate.

As non-poisonous spider killers we now have chlorinated compounds such as CPCBS (chlorfenson) which act mainly as ovicides.

FUNGICIDES AND SELECTIVE WEEDKILLERS

Many of the newer fungicides are organic forms of sulphur. These are generally less likely to damage the plant than are the inorganic forms such as lime sulphur. Examples are thiram, zineb, ziram, and ferbam. Another fungicide recently introduced into this country is captan and this has found particular uses against apple scab, and as seed dressings.

Perhaps the most spectacular modern development has been the use of the growth-regulating or hormone-type selective weedkillers. Two of these, MCPA and 2,4-D, have become common names in the farming community.

"Gammasan" seed-dressing trial for the control of flea beetle. *Left*: dressed seed was sown; *right*: untreated seed, with comparatively thin stand.

Imperial Chemical Industries at Jealotts Hill can claim priority in discovering MCPA; 2,4-D was discovered almost at the same time at Jealotts Hill and in the U.S.A. Before the 1939–45 War, weedkilling in cereal land was a hazardous business; today it is so safe and inexpensive that about one-third of Britain's cereal acreage is sprayed every year.

Two additions to this range are now in general use. 2,4,5-T is for use on woody plants such as brambles and brushwood; MCPB is rather safer than MCPA on pastures containing young white clovers.

The most recent advance in this field is the discovery of CMPP, a cereal weed-killer for control of chickweed and cleavers, important weeds which are resistant to MCPA and 2,4-D.

One of the biggest needs is for safe and reliable weed-killers in vegetable crops where the hormones cannot be used.

APPLICATION METHODS: SEED DRESSING

Many means have been devised for applying crop protection chemicals but, apart from baiting, which has rather specific uses, they may be considered under three main headings: spraying, dusting, and seed treatment.

Seed treatment, or seed dressing as it is usually called in England, will be considered first, since it is the simplest and least expensive of all crop protection methods.

One of the most widespread diseases of cereals is bunt of wheat. In olden times, to grow wheat was to have bunt; today serious attacks occur only where the seed is not treated with chemicals to kill the spores of the fungus. The main chemicals used against bunt and other seed-borne diseases of cereals are the organo-mercurials, and their use has been standard practice in this country since the early 1930's. The organo-mercurials also protect against soil-borne fungi which attack the seedlings, particularly in cold, wet seasons.

The most important post-war seed-dressing development has been the addition of insecticides to give protection against wireworm as well as disease. The layman is surprised by the small quantity of chemical used in seed dressings. A little more than 1 oz. of gamma BHC protects an acre of wheat against attack by half a million wireworms; 1/20 of this quantity of organo-mercury protects against disease. The quantity of gamma BHC used in a cereal seed dressing is so small that it is well below the level at which it can taint a following susceptible crop such as potatoes.

Concurrently with the development of insecticidal dressings for cereals, seed dressings were developed for other

crops. On vegetables, for example, organic fungicides such as thiram are preferred to organo-mercurials since they are somewhat safer on small seeds and give better results against soil-borne diseases which are generally the more important ones on these crops.

Almost every seed sown will benefit from some form of seed treatment. In Great Britain almost all seed dressings are applied as dusts. Overseas there is an increasing use of liquid dressings to avoid the dust hazard of powder dressings.

SPRAYING AND DUSTING

When the hormone weedkillers were first introduced they were marketed as dusts to be applied by a fertiliser distributer. In a country such as the U.K. where water is readily available, spraying is obviously preferable since it gives better distribution of the chemicals, and the cost and carriage of the inert filler in a dust is saved.

Ten years ago few individual farmers possessed spraying machines and those in existence were able to apply the chemical only in volumes of 100 gallons or more of water per acre. However, by using smaller jets it was found possible to apply selective weedkillers in volumes of water as low as 5 gallons per acre. Today many thousands of low-volume farm sprayers are in use throughout the country. In the low-volume ground sprayer the spray falls from the boom by gravity; when spraying into trees or bushes some means must be found for carrying the spray upwards. This is achieved by means of a powerful blast of air and all low-volume fruit spraying is carried out by air-blast machines.

Low-volume techniques are now being developed for almost all crops. For example, the aerosol system of applying insecticides in glasshouses is really an extreme form of low-volume spraying.

With the development of low-volume spraying, dusts have been less widely used in this country. Overseas, however, particularly in countries where water is not readily available, dusting is still used. Recent machinery developments include small portable power dusters which can be carried by one man in country where it is not possible to use heavy-wheeled equipment.

SOME FUTURE TRENDS

Although we now have many new chemicals they all have their limitations and we are still handicapped by the lack of fundamental knowledge as to exactly how they work. This fundamental knowledge is essential if we are to prepare new materials by design rather than discover them by accident or by trial and error, as has so often happened in the past. In this work the chemist, the physicist, the biologist, and the engineer must each play his part.

For example, for many years apple scab has been prevented by spraying with sulphur preparations, which give good protection but are liable to damage sensitive varieties. Recently a new fungicide, captan, was introduced. It gives better protection than sulphur against the disease, causes less damage, and results in higher yields of better quality fruit. Unfortunately captan has little effect on another disease, apple mildew. Mildew is reasonably well controlled by sulphur sprays, but where captan has been used, heavy attacks have frequently developed. A number of solutions to the problem have been suggested, but they are all compromises. We need a new fungicide with the efficiency and safety of captan against scab, together with protection against apple mildew.

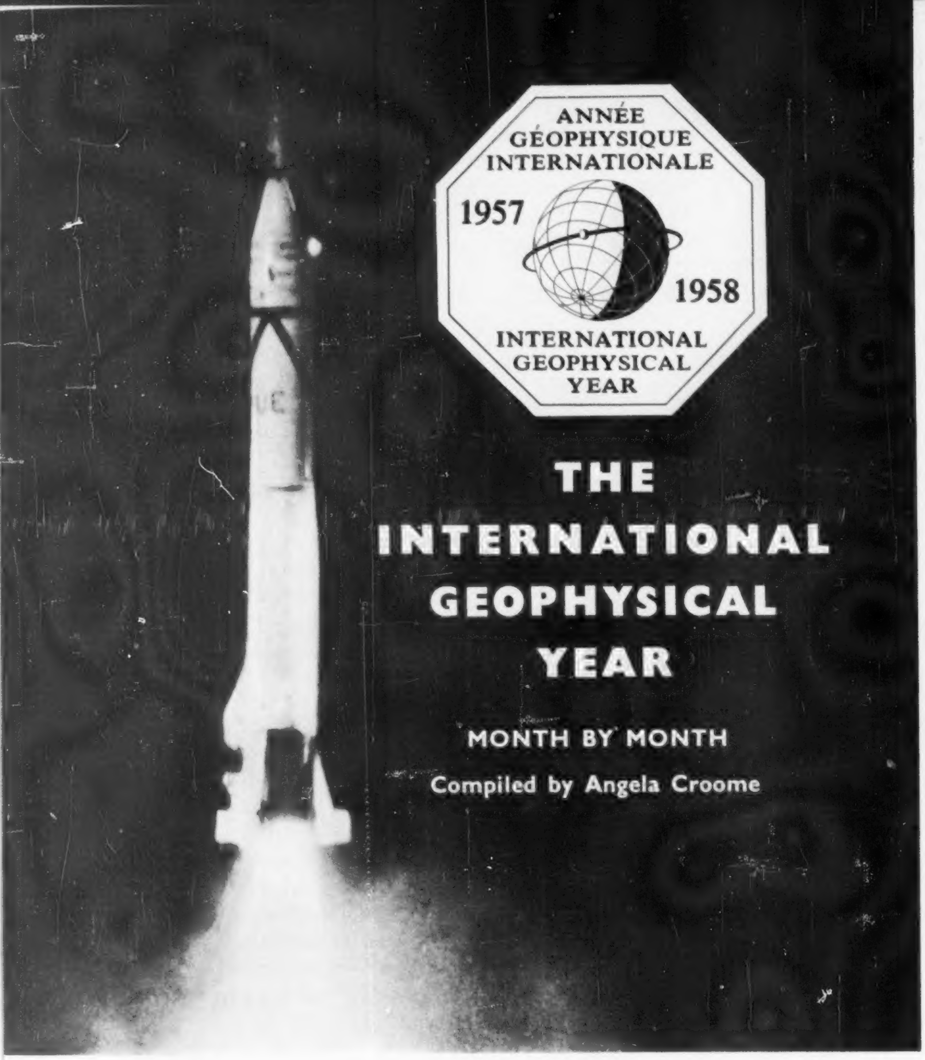
Similar examples can be quoted in almost every aspect of crop protection, which is a very young science. Everywhere, from laboratory to field, it is necessary to increase the tempo and volume of research.

CHEMICAL NAMES OF THE NEWER CROP PROTECTION CHEMICALS

As recommended by the British Standards Institution

Recommended Common Name	*Chemical Name*
DDT	Dichlorodiphenyltrichlorethane (technical DDT is a complex mixture in which *pp'*-DDT predominates) *pp'*-DDT = 1:1:1-trichloro-2:2-di-(*p*-chloropheny)ethane
BHC	Benzenehexachloride mixed isomers of 1:2:3:4:5:6-hexachlorocyclohexane
Aldrin	1:2:3:4:10:10-hexachloro-1:4:4a:5:8:8a-hexahydro-exo-1:4-endo-5:8-dimethanonaphthalene
Dieldrin	1:2:3:4:10:10-hexachloro-6:7-epoxy-1:4:4a:5:6:7:8:8a-octohydro-exo-1:4-endo-5:8-dimethanonaphthalene
Endrin	A stereoisomer of dieldrin
Parathion	diethyl *p*-nitrophenyl phosphorothionate
Schradan	bis-NNN'N'-tetramethylphosphorodiamidic anhydride
Chlorfenson (CPCBS)	*p*-chlorophenyl *p*-chlorobenzene sulphonate

Recommended Common Name	*Chemical Name*
Thiram	bis (dimethylthiocarbamoyl) disulphide
Zineb	zinc ethylene-1:2-bisdithiocarbamate
Ziram	zinc dimethyldithiocarbamate
Ferbam	ferric dimethyldithiocarbamate
Captan	N-trichloromethylthiocyclohex-4-ene-1:2-dicarboxyimide
Metasystox (demeton--methyl)	A mixture of demeton-0-methyl and demeton-S-methyl demeton-0-methyl = 2-ethylthioethyl dimethyl phosphorothionate demeton-S-methyl = S-2-ethylthioethyl dimethyl phosphorothionate
MCPA	4-chloro-2-methylphenoxyacetic acid
2,4-D	2:4-dichlorophenoxyacetic acid
2,4,5-T	2:4:5-trichlorophenoxyacetic acid
MCPB	γ-(4-chloro-2-methylphenoxy) butyric acid
CMPP	4-chloro-2-methylphenoxypropionic acid



THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Explorer

Just before 11 p.m. (local time) on the last day of January, the U.S. Army's *Jupiter-C* rocket launched from Cape Canaveral, Florida, placed the first American satellite in an orbit nearly 2000 miles above the Earth. The launching flight took seven minutes.

The *Jupiter-C* is a step-rocket of which the main element is the Army's *Redstone*. On this occasion the first (*Redstone*) stage was powered by Hidyne, one of the new "exotic" fuels which is said to have developed a thrust of more than 78,000 lb.

The satellite's orbit lies in a plane forming an angle of 35° with the equator. Its farthest point north is therefore about the latitude of Gibraltar, and south the tip of Africa. It will not approach nearer than 800 miles to Britain nor pass over Russia at all. This was expected from the advance information given about the intended orbits of the American satellites and the tracking stations (Minitrack) are in accordance with this plan. Nevertheless the radio signals may occasionally be picked up and indeed were heard by the BBC listening post at Tatsfield within a few days of launching.

The satellite, *Explorer*, launched by the *Jupiter-C* is a tube 6 ft. long by 6 in. in diameter with a temperature probe jutting out ahead of it. Its all-up weight is 30 lb. with 10 lb. of that absorbed by the payload of instruments. Two transmitters are carried, one operating on the prearranged frequency of 108 Mc/s, the other on 108·3 Mc/s and both giving a continuous signal. The transmitters are of different powers; the low power unit is expected to last for several months.

Tracking depends essentially on the twelve Minitrack stations of which a group lie in a line north and south down the American continent, one is in the West Indies, one in South Africa, one in Australia, and one at Singapore. Each is equipped with the elaborate radio equipment designed to "fix" the satellite within narrow limits (and from which tape recordings of the telemetered scientific data will be obtained for analysis in the U.S.), and with the special wide angle Schmidt tracking cameras.

Explorer I was equipped with a Geiger-counter for measuring the intensity of cosmic radiation, with microphones for registering impacts by micrometeorites, and with temperature gauges for inside and outside temperature measurements.

By the time this comes to be read it is quite probable that several other satellite-launching attempts will have been made. The U.S. Army planned to fire a second almost immediately and the Russians were said to be preparing for the firing of *Sputnik III*. The U.S. Navy failed in the attempt to launch another *Vanguard* in February.

Satellite 1957

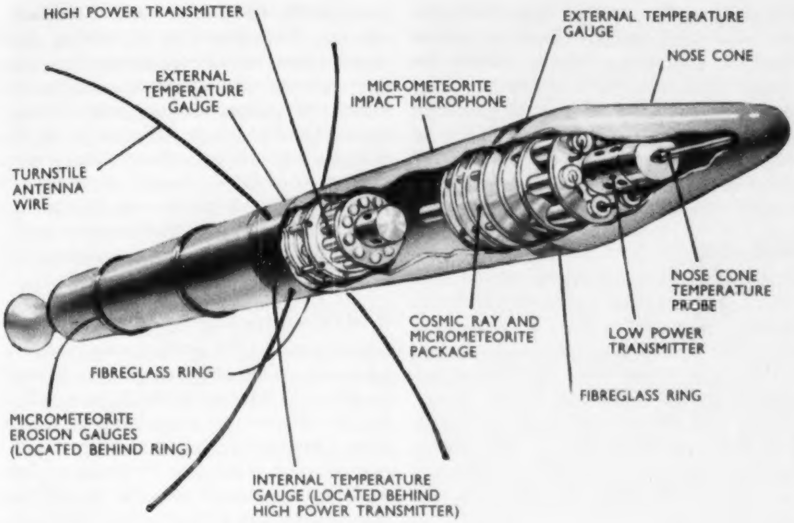
The Smithsonian Astrophysical Observatory (the co-ordinating body for "Moonwatch" activities) has suggested that artificial satellites be treated "observationally and orbitally" as comets. A tentative notation, as follows, is proposed:

- 1957 α1—the first satellite's rocket-carrier;
- 1957 α2—the first satellite (instrument-carrier);
- 1957 β —the second satellite.

In the case of launchings where more than one object went into orbit, numbers following the Greek letter indicate the

	ORBIT							
	Speed	*Perigee*	*Apogee*	*Initial Period*	*Angle of Path to Equator*	*Payload*	*Inboard Research*	*Radio*
Sputnik I October 4, 1957	18,000 m.p.h.	125 miles	560 miles	96·2 mins.	65°	184 lb.	Air temp.	40·002 Mc/s 20·005 Mc/s
Sputnik II November 3, 1957	17,840 m.p.h.	170 miles	1055 miles	103·7 mins.	65°	1118 lb.	Living conditions in Space, Cosmic rays Solar x-rays	40·002 Mc/s 20·005 Mc/s
Explorer I January 31, 1958	18,000 m.p.h.	219 miles	1700 miles	114 mins.	34°	10 lb.	Air temp. Cosmic rays Micro-meteorites	108 Mc/s 108·3 Mc/s

Comparison of IGY satellites data at launching.



Components of *Explorer I*.

objects in inverse sequence of brightness. All observations of $\alpha 1$ give the second magnitude; estimates of $\alpha 2$ range from fourth to sixth magnitude. On January 31, *Explorer* 1958α, the first U.S. satellite, went into orbit.

Ice-cover in the Antarctic

More data is coming in all the time from different expeditions about the extent and depth of the ice-cover in Antarctica. This month should bring the result of the first transcontinental profile ever made—that being carried out by Dr Fuchs and his party between the Weddell and Ross Seas. Dr Fuchs hopes to reach Scott Base during the early part of March.

Capt. Finn Ronne's party, operating from Ellsworth station on the Weddell Sea, recently made the surprising discovery that a large island underlies the Filchner ice-shelf. At this preliminary investigation the island appeared to stretch 200 miles in one direction and 180 in another; much of it is several hundred feet above sea-level. The island seems to be indented by three wide bays, one of them 50 miles deep.

The Australians probing an unmapped area 300 miles into the interior from Mawson have detected 3000-ft.-high mountain ranges sheathed by a further 5000 ft. of ice. Elsewhere during their traverse they have sounded ice 8500 ft. deep.

The French have reported that there is 9000 ft. of ice beneath their magnetic pole station of Charcot. As the station itself stands at about 7200 ft. (2400 m.) above sea-level the ice-cover here appears to extend below the sea.

In western Antarctica, north-west of the Wright Glacier, a New Zealand party from Scott explored an extensive ice-free area standing above the 1000-ft. contour and occasionally rising to over 5000 ft. The central feature of this area was a lake 4 miles long by 1 mile wide and situated in a desert-like basin of loose sand and grit once traversed by a 20-mile-long glacier. The lake, only partially iced over, seems all that remains of the once impressive glacier. At the height of the summer, the period when the New Zealanders inspected the area, water was flowing through the lake via streams at either end. The lake was described as biologically sterile but primitive water-plants were observed in small pools near by. A patch of lichen 2 yards across was found among the surrounding hills—the only other indication of life in the region.

During the course of the trip the New Zealanders found the remains of three crab-eater seals at a height of 2000 ft. These seals frequently make long journeys from the coast up glacier valleys, as reported by the *Discovery* expedition.

Arctic Basin's Chequered Career

Three times during the past 50,000 years the Arctic Basin has been entirely cut off from the Atlantic Ocean, according to the recently announced results of Russian oceanographers. They have come to this conclusion after a comprehensive study of samples of ocean bottom sediments collected over the past few years by Arctic expeditions and from the stations set up on drifting ice-floes.

During these periods when the Basin was cut off from the warmer waters of the Atlantic Ocean ice accumulated and this in turn contributed to an increase in the coldness of the climate. This was one of the decisive factors in the occurrence of the quaternary glaciation. Prof. Yakov Gakkel (discoverer of the Lomonosov Ridge in the North Atlantic) believes that the quaternary glacial and inter-glacial sediments found on the Lomonosov Ridge correspond to similar sediments to be found on the Asian mainland today.

FIG. 1. Dr Fuchs (*right*) arriving at the South Pole and shaking hands with Sir Edmund Hillary. (This photograph and the one on the next page were taken by a *Times* staff photographer and radioed from Scott Base to Wellington, New Zealand.)

FIG. 2. Dr Fuchs at the South Pole, after having been delayed by a strenuous scientific programme and bad terrain.

This suggests that at periods when direct connexions between the Arctic Basin and the Atlantic were interrupted, not only the Nansen Ledge and the continental shelf of the Barents Sea but the Lomonosov Ridge as well were exposed. It has been found by age tests making use of the technique of radioactive decay that the upper layer of bottom sediment, between 24 and 30 inches thick, was laid down within the last 50,000 years. This accumulation shows three stripes of grey silt with brown layers in between. The brown layers have been found to contain plentiful traces of the *Rhizopoda* which occur among the plankton of the North Atlantic. The grey layers do not.

Russian geologists have now compiled the first ground map of the Arctic Basin in which the two main areas of sedimentation are shown near the marginal Atlantic and the marginal Pacific sedimentation divided by the Lomonosov Ridge.

New Ridge Beneath Arctic Ocean

American scientists operating from IGY Drifting Station A recently detected a submarine ridge rising 5000 ft. from the ocean floor in the region of 86° N., 140° to 180° W. The drifting station tending to the north passed across the ridge, which appears to be a major feature, running generally east and west, parallel to the great Lomonosov Ridge which slices the Arctic Basin in half from Ellesmere Island nearly to New Siberia. The presence of the ridge was indicated by seismic soundings from the floe, and confirmed by corresponding changes in the gravity readings. South of the ridge the ocean bottom lies at 10,000 ft. deep; the ridge therefore rises to within 5000 ft. of the surface. The question is, how far does the new ridge extend? Does it perhaps form a continuous barrier across the Arctic Ocean as the Lomonosov Ridge does? If so, it would have a profound effect on the mixing and circulation of water in the Basin. Hydrographic tests of the mass of water in different localities should establish the point.

Halley Bay

The MV *Tottan* left Southampton with four relief personnel and stores for Royal Society Base, Halley Bay, on November 18. On this voyage she also carried reliefs and stores for the Norwegian expedition in Dronning Maud Land. *Tottan* reached Norway Base on Christmas Day and Halley Bay on New Year's Eve—the earliest arrival she has achieved on any of her three trips south for the Royal Society.

On her return she is conveying back to England the 1957 leader at Halley Bay, Col. Robin Smart, RAMC, who was given only a year's leave of absence by the War Office for his Antarctic duties. He was injured in a fall on the ice early this Antarctic spring but has made a good recovery.

The party at Halley Bay will be led for its final year by Mr Joseph MacDowall of the Meteorological Office who has already been in charge of the station's meteorological team during 1957.

The Royal Society Base had a unique opportunity to observe the IGY's first total eclipse of the Sun on October 23. This eclipse was observable only from a very small area of the Earth's surface and the actual path of totality lay over the sea off that part of the Antarctic washed by the Atlantic (an impractical position from which to watch it). Halley Bay was therefore the nearest IGY station to the region of totality. Weather was fine during the eclipse and good observations were achieved.

Since the Moon's shadow touches the Earth in this polar region it struck the surface obliquely so that the eclipse centre in fact lay in the atmosphere above the Earth, not at the surface. This made the eclipse particularly suitable for studying the effects on the ionosphere of solar ultra-violet light. Ultra-violet from the Sun causes electrons to become detached from uncharged gas atoms and a layer of charged particles is thus formed, a lower limit being set by the absorption of the ultra-violet by the ozone layer of the atmosphere. Regular observations of the ionosphere enable the electron densities at various heights to be determined and such measurements are made at Halley Bay. During an eclipse the ultra-violet radiation is cut off just in the same way as the visible light, and changes therefore occur in the electron content of the ionosphere. The objectives at Halley Bay were to observe this variation and to compare ionospheric conditions during the eclipse with those obtaining on adjacent days. On the days either side of the eclipse ionospheric observations were stepped up from hourly intervals to quarter-hourly intervals; on October 23 itself continuous observations were maintained. The weather was fortunately clear.

First Open Seas Gravity Measurements

The first successful surface measurements of gravity in the open sea were performed by Dr J. L. Worzel of the Lamont Geological Observatory, operating from the USS *Compass Island*, 200 miles south-east of New York last November. Previously it has been impossible to measure gravity over the 80% of the globe's surface that is covered by water because the waves' tossing disturbed the instruments' readings. Therefore the measuring of gravity over the great substance of the globe has, up till now, depended upon work done from submarines. These, to date, have amounted to a mere 4000 readings, half of which may be accounted for by the Lamont Observatory.

The present series were carried out along a line extending from the deep ocean basin across the continental slope and on to the continental shelf, a track that had previously been "gravity-swept" from the submarine *Tusk* in 1947. The agreement of the two sets of measurements proved very satisfactory. It is now hoped that the *Vema*, Columbia University's research ship, which is shortly to set out on a long cruise of the South Atlantic, Indian Ocean, and the Mediterranean, will carry a similar instrument and so fill some of the many gaps made by the Earth's areas of water in the pattern of world-wide gravity records.

The new sea-gravimeter has been developed by Dr Anton Graf of Munich from an Askania instrument. Essentially its operating principle is that of the spring-balance. During use it is mounted on a gyro-stabilised platform. The measurements carried out from the *Compass Island* off New York took nine hours as against the two days required for the submarine measurements; reduction of the data took half a day, in contrast to the two weeks needed to correct and compute data collected by *Tusk*.

"The North Wind Doth Blow . . ."

Observations from *Aerobee-Hi* rockets fired from the Fort Churchill rocket site in the north of Canada have shown that winter winds at height above the Earth in this area sometimes travel at the enormous speed of 335 m.p.h.

Second Tropopause Over Antarctic?

The IGY Antarctic Weather Centre has been in operation for just about a year. Characteristic tendencies in the Antarctic's weather are already discernible from the mass of reports flowing through the bureau. It appears that there may be a second tropopause above Antarctica, for instance. This has been observed between the 50- and 20-millibar level—that is, at heights of about 19–20 km. No explanation for this feature is offered. A careful watch is being maintained for further revealing developments.

Another curiosity is that temperatures in this area sometimes vary by as much as 100 degrees between points no more than 850 miles apart.

The existence of a deep cold cyclone at height above the Antarctic has now been confirmed. This feature had previously been postulated but not directly observed. The cyclone is not stationary but varies considerably from day to day both in position and in intensity.

During 1958 meteorologists from Argentina, Australia, Belgium, France, South Africa, and the Soviet Union will be at work at the AWC as well as American weather-men.

Second Visit to Ellesmere Ice-cap

Last summer a team of eight Canadian scientists carried out a preliminary field programme in the Lake Hazen area of Ellesmere Island, at 82° N., 70° W. Some members of the party penetrated on to the ice-cap of the interior which has only once before been visited, by the Oxford University Ellesmere Land Expedition. The Canadians established that the principal feature, Mt Oxford, rises to a height of 7300 ft. and not 9000 ft., as claimed by the Oxford expedition.

The base camp was established on the northern shore of Lake Hazen at 520 ft. above sea-level. The first stores, including a bulldozer, were flown in by a RCAF C47 on to an unprepared landing-strip. The bulldozer then set-to to clear a 3500-ft. runway for use during the remainder of the airlift operation. Then an advance camp 3500 ft. up on the Gilman Glacier and 40 miles north-east of the lake was also established by airlift. A glaciological team of six men moved into the advance camp and for two months pursued accumulation and ablation studies along the glacier, from its snout at 1300 ft. to the summit of the ice-cap at 6000 ft. At the camp, ice-temperatures and crystal structure were studied down to 50 ft. On the ice-cap a 20-ft. pit gave similar readings, carrying the weather information back to 1930, in the opinion of the Canadian glaciologists.

The two men left at the base camp by the lake were mainly concerned with geological and limnological work. They also maintained a met.-record.

The summer field party was replaced by a four-man wintering party in mid-August, the U.S. light ice-breaker *Eastwind* providing the support. This summer the main field work will be carried out by a large party.

The Arctic Division of the Defence Research Board is organising this work and Dr G. Hattersley-Smith of the Board is in charge.

Glaciers of Mount Kenya

In December, a two-month expedition to the glaciers of Mount Kenya started work. Comparison of present conditions with those evident in old photographs of the mountain's glaciers suggest there has latterly been considerable recession of the ice in the area. Glacier retreat may be due to greater direct heat from the Sun, to a decrease in snowfall, to more frequent warm airs from the sea, or to a combination of these. In Europe warmer summers and a rise in the temperature of the surrounding seas seem to be the main factors. But in central Africa much less is known of conditions over the years. The Mount Kenya IGY Expedition, which is supported, among others, by the Royal Society, hopes to remedy this situation at least in relation to this mountain, and its work is also designed to provide a baseline for subsequent periodical studies. The glaciers of this mountain, of Kilimanjaro (to which the University of Sheffield sent an expedition in 1957), and of the Ruwenzori range, where work is being carried out by the Institut des Parcs Nationaux du Congo Belge, are of special interest since they are the only glaciers in equatorial Africa, some of the few that are accessible anywhere in equatorial regions. The latitude of Mount Kenya is 0°10′ S, 37°20′ E.

The party of fourteen men led by Dr I. S. Loupekine, a physicist, established its base camp at 13,500 ft. up the mountain. From there glaciologists and surveyors proceeded to secondary camps at 16,000 ft. to record the position, size, and activity of all the glaciers on the mountain. They also provided ground control for an aerial photographic survey being carried out by Hunting Aero Surveys. The net annual accumulation of ice was to be assessed.

Below this point two meteorologists and a hydrologist recorded the weather on different parts of the mountain, and studied the drainage into the valleys. A geologist was to attempt to trace back the glaciological past of Mount Kenya. The biologist studied the movements of animals and plants at the shifting ice-margin. The period of the expedition has been chosen with some care so that the first half of the field work coincided with the end of the rainy season while the second part was dry.

A preliminary reconnaissance was carried out on the mountain in July.

UNESCO Survey of IGY Films and TV

Film and television producers in many countries are recording various aspects of the scientific research carried out during the International Geophysical Year so that the general public may know more about these activities. It is, however, difficult in any one country to cover the vast scope of operations, and for this reason UNESCO is making a survey of material being prepared in its member states. The information is being passed on to TV stations all over the world so that exchanges of programmes and films can be made direct.

Fifteen countries have already indicated that they have prepared films or that productions are in hand. In the United States, thirty-nine short colour-films have been produced in collaboration with a television station in Boston. In the U.S.S.R., four colour-films are available of Soviet expeditions to the Arctic and Antarctic. Japan has produced colour-film on research in the ionosphere, while in the Netherlands plans are going forward for a series of short films in colour on research in such fields as geomagnetism, radiophonic disturbance of solar origin and measurement of longitudes and latitudes.

Among the twelve countries which have so far announced television shows, the United Kingdom has produced an important programme devoted to IGY research generally, which was presented by the Duke of Edinburgh over the BBC on July 1, the opening day of the "Year". Previously, Associated-Rediffusion had screened a series of eight programmes, "A Year of Observation", with which the first science TV broadcasts in England were inaugurated. Switzerland has broadcast two TV programmes, one on research equipment for the Antarctic and another on glaciology work on the Jungfraujoch. In Belgium, three films for TV have been produced dealing with Belgian institutes taking part in IGY research, and another on the North Pole explorer Adrien de Gerlache. The Czechoslovak TV network has made a short film and plans others during the "Year", which will be available on an exchange basis.

At the end of the International Geophysical Year, UNESCO intends to gather together as much TV and film documentation as possible in order to prepare a film record of the international effort as a whole.

THE BOOKSHELF

Shackleton

By Margery and James Fisher (*London, James Barrie Books Ltd, 1957, xvi+ 559 pp., 30s.*)

Contemporary, or almost contemporary, biography is a difficult, if never more important, task in these days of swift change and multitudinous affairs: days in which the biographer, if embarrassed by the great mass of material through which he has to wade, is well aware how evanescent the records may be. The authors have dealt exhaustively and fairly with a man who had immense drive and complicated character. The few of us who served in the Antarctic with both Scott and Shackleton were wont to crystallise the comparison when we met subsequently (on occasions far too seldom for our wishes and our needs) by saying that, while by all workaday ethical standards, Scott was the better man, Shackleton was, to us, the more inspiring leader. Both were capable of engendering in the individual the utmost loyalty and affection, but Shackleton was more of an extrovert: made his impact more rapidly and more deeply affected a greater proportion of his men. Curiously enough, the weaknesses which Shackleton displayed in civilisation (of which all his men were well aware, and from which some of them undoubtedly suffered), while they were temporarily exasperating, in the long run deepened the affection which Shacklton's men had for their leader whether he had led them to failure or to success. Those weaknesses are fully and sympathetically dealt with in this "Life". The impression is vivid of a great and lovable, but fallible and vulnerable, man moving from height to height and from crisis to crisis, acquitting himself superbly when engaged upon his chosen vocation, but bound, if he continued his course long enough, to be overwhelmed eventually through his own shortcomings in the civilisation to which he perforce returned, if he returned at all.

Shackleton, Amundsen, and Scott were all "lovely in their lives", and they were all fortunate to die in mid-career at the peak of their reputations and having made an impact in their own particular sphere which, though not matchless, yet has been, and will be, not easily matched.

The writer cannot agree with the authors that their subject was the greatest of all polar explorers; with Fridthjof Nansen in the field, this is, in his opinion, too much to claim. But Shackleton is not far behind, though he breasts the four-dimensional tape with one or two contemporaries and with a predecessor or two whose objectives were not so spectacular nor so well publicised. It is surely good enough to be bracketed with Scott, Amundsen, Peary, Cook, Mawson, McClintock, and Nordenskjold. To this galaxy Byrd should be added, for he applied modern technology to Antarctica with splendid success, though, as a leader, Byrd blotted his copybook badly through the exploit for which the majority of his fellow-citizens and fans would acclaim him most: his winter venture "alone" on the ice-shelf a hundred miles distant from the responsibility he had assumed as a leader and owed it to himself to discharge. That is one thing Shackleton, when leader, could never have done, though he had the guts, temperament, and know-how to have carried the venture through had he undertaken it, as August Courtauld did on the Greenland ice-cap, as a subordinate volunteer.

Nothing in the book appeals to the writer more than the fair and full treatment the authors have given to those three rather controversial episodes: the Scott-Shackleton controversy; the blank letter sent to Scott after the Nimrod Expedition, and the episode of the fourth man on the South Georgia crossing. Two incidents particularly emphasise the dominant elements of Shackleton's character. It is utterly characteristic of him, replying to admonitions to "rest" while his men were in peril, to say, "The only path he could walk [he did not trouble to mention the idea of rest] was between the slaughter-house and the graveyard, and he could not guarantee to follow this depressing path for two months or so."

It was equally true to character when he requested his men, after the rescue from Elephant Island, to keep their hair and beard for publicity purposes. It will be a long time before this book is superseded as the authoritative "life" of its great subject, and the larger circulation it has the better for the country that produced him and holds him in the honour he deserves.

R. E. PRIESTLEY

Perspectives in Biology and Medicine

Any new journal in these days must anticipate at the best a cold welcome. Only those offspring can expect to survive which contribute quickly to the welfare of the previous generation. Subjects of increasing complexity justify the production of journals of greater technicality, and editorial boards are stern—so much sterner than the same individuals when responsible for organising a conference—in demanding facts and nothing but facts, if not the whole facts. The arts of scientific research can be given little expression in journals whose editors are faced with problems of space and rising costs. It appears that there is justification for a new journal devoted to ideas and to the organisation of facts into concepts.

Such is the purpose of *Perspectives in Biology and Medicine*, published by the University of Chicago Press, under the editorship of Dwight Ingle and S. O. Waife, the first quarterly number of which, for autumn 1957, has recently appeared. The British members of its Advisory Board are Sir Henry Dale and Dr G. E. W. Wolstenholme. The first issue contains invited essays on biochemical genetics in man, medical education, non-endocrine aspects of stress, the action of insulin, "normal" healthy young men, psychoanalysis and human freedom, and an experiment in group therapy, all most readable.

The Editors are to be congratulated on the contents and format of this first issue, and future numbers will be awaited with an eagerness such as can be accorded to all too few of the many journals now reaching the scientist's desk.

Pain and Pleasure: A Study of Bodily Feelings

By Thomas S. Szasz, M.D. (*London, Tavistock Publications Ltd, 1957, xvi+ 301 pp., 30s.*)

The problem of pain remains one of the most intractable in anatomy, neurophysiology, medicine, and psychiatry. Pain is not nowadays counted among the "passions of the soul" outlined by Aristotle, and the "intensive" theory of pain, originally advanced by Erasmus Darwin, has given way to the "sensory" theory. Nevertheless, a great many difficulties remain and obstinate facts are unaccounted for. No anatomical nucleus in the brain has been identified which must be reached by the so-called pain-conducting fibres before there can be awareness of pain; there is no known cortical representation of pain as there is for vision, hearing, and the other senses. Nor is there any "natural" stimulus for pain as there is for these senses. How do we explain psychogenic pain? What about the horrible but apparently painless self-mutilation of psychotics, the ecstatic martyrdom of saints, the induction of pain under hypnosis,

masochistic pleasures, and the relation between pain and anxiety?

Dr Szasz is well aware of these problems. He is also conscious of the philosophical presuppositions about the body-mind relationship which underlie current studies of pain. He proposes to overcome these difficulties by an extension of psychoanalytic theory, from which, as he remarks, a consideration of pain has traditionally been excluded. He suggests accordingly that we should recognise three "components" or concepts of pain. First, pain can mean a signal of danger to the body; this is an *intra*-personal message. Secondly, the pain may be understood as including a request for help from another person; this is *inter*-personal as well. Thirdly, pain may not refer to the body at all but simply signify a request for help, a complaint about unfair treatment, or a demand for punishing a hated object; that is, the "pain" may exclusively mean an *inter*-personal communication.

Dr Szasz deserves to be congratulated for his interesting attempt to embrace the medical notion of pain and the psychiatric conception of anxiety in a single formula in this fashion. The plausibility of his view speaks highly for the flexibility of Freudian theory, in spite of its unattractive jargon; even the much-used word "ego", defined as "a cohesive organisation of mental processes" is far from clear in Dr Szasz's text. In the course of his discussion, which is occasionally marred by obscure passages, he makes a number of original and penetrating observations. I would single out, in particular, his view of self-mutilation as an attempt to make the body correspond to the psychically amputated body image, and the parallel he draws between mourning and reactions to a phantom limb.

The second part of the book is an attempt to develop a theory of pleasure as an additive phenomenon arising from the accumulation of pleasurable items; pleasure as the discharge of tension being a special case of his. While the author in this part makes a number of incisive remarks, his general conception is laboured and carries little conviction. His treatment of pleasure is not on a par with his theoretical analysis of pain, which must be regarded as his important and principal contribution. J. COHEN

Atomic Energy in Agriculture

By W. E. Dick (*London, Butterworths Scientific Publications Ltd, 1957, x+150 pp., 15s.*)

This book is an ambitious attempt to put before the layman a general account of recent work on the use of isotopes in those biological sciences that are important in agriculture. By careful choice of material, by enthusiasm for his subject, and with the help of some very clear photographs, the author largely succeeds in giving a competent summary of a wide field of work. Whether all of it will be comprehensible to a layman is more questionable. Most of the topics discussed require some knowledge of chemistry and biology.

The first long chapter, "Remaking Crop Plants with Radiation", is followed by one on the use of isotope-labelled compounds, particularly carbon, in the study of photosynthesis. These chapters are the most difficult sections of the book. They contain summaries, very competently presented, of some recent work in these fields that was described at the conference on the peaceful uses of atomic energy at Geneva in 1955. The next two chapters deal with the use of radioactive materials in crop nutrition, in the study of insecticides, and in the movement and destruction of insect pests. Chapter 5 is devoted to applications of isotopes to forestry, and contains interesting accounts of root grafts, the rate of movement of nutrients in trees and the spread of fungal diseases (oak wilt) using spores labelled with isotopes of iodine and silver. The final long chapter describes the use of ionising radiations for preserving meat, fish, and vegetables.

So many topics are discussed within 150 pages that it is difficult to quote examples which best illustrate the simplicity of many of the varied techniques developed during the past decade. Apart from the movement of nutrients in plants mentioned above, the study of the sterilisation of larvae of the American screw-worm fly (pp. 83–4) and the decomposition of DDT within resistent and non-resistent insects (pp. 93–4) deserve mentioning. The direct irradiation of pork appears to provide a safe method for eliminating the risk of trichinosis (p. 136) in countries where the standards of food inspection are less exacting than in the United Kingdom. It is more doubtful, however, whether the use of labelled fertilisers (pp. 61–8) provides more *practical* information on manuring crops than can be obtained from experiments using unlabelled fertilisers, although the value of isotopes, especially ^{32}P, in soil science is undisputed.

An introductory chapter outlining the scope of the book, describing technical terms, which are mainly defined in footnotes, would have made reading easier. Too many names of research workers are given in some places for a general review of this kind; due credit to the main workers in the different fields could have been ensured by including a short bibliography at the end of each chapter. There are a few errors of fact, and on pages 68 and 77 "millicuries" should read "microcuries".

"Atomic Energy in Agriculture" is reasonably priced and very up to date; it should find a place in many school and public libraries, and will make enjoyable reading for those with interests in other branches of science. G. E. G. MATTINGLY

Chemistry: The Conquest of Materials

By Kenneth Hutton (*London, Penguin Books Limited, 1957, 228 pp., 3s. 6d. net.*)

Although perhaps the most fundamental of the sciences, chemistry lends itself least to popular exposition. An attempt to start from scratch and explain both its principles and its major industrial applications within a modestly sized volume such as this is necessarily extremely difficult. Mr Hutton is to be congratulated on the skill with which he goes about his task, and the measure of success he achieves. The first quarter of the book, devoted to principles, provides a good foundation for the discussion of chemical processes which follows. The latter covers a great deal of ground, and there are few substances of importance which are not at least mentioned.

Nevertheless, one cannot help feeling that it is those with a smattering of chemistry—and indeed those with a considerable knowledge, if they do not happen to be working in the industrial field —who will find the book most useful. Those with literally no prior knowledge whatsoever will have to be made of stern stuff if they are to read straight through the book and have at the end a clear understanding of what it is all about. But this is an indication of the difficulty of marshalling and simplifying chemical knowledge rather than a criticism of Mr Hutton's skill as an expositor. The book concludes with an excellent bibliography so that those whose appetite for chemistry is whetted—and it is to be hoped that these will be many—can read more widely. T. I. WILLIAMS

Experimental Crystal Physics

By W. A. Wooster (*Oxford, Clarendon Press, 1957, vi+115 pp., 18s.*)

This welcome monograph fills an empty space in the already vast literature dealing with crystals. It is essentially a guide to an elementary experimental course on the physical properties of crystals, other than X-ray crystallography. It is in fact a laboratory manual for teaching experiments in crystal physics and is based upon the course built up by Dr Wooster at the department of Mineralogy and Petrology at Cambridge University. True to Cambridge tradition, the experiments described all use simple means and are successfully designed to illustrate basic principles.

Despite a mere hundred pages, the monograph contains a tremendous

amount. Chapter I, optical properties, is concerned mainly with determination of refractive indices and optical constants. Chapter II describes experiments to yield measures of dia- and para-magnetic properties. Thermal properties are covered in Chapter III, and these include (*a*) conductivity, (*b*) thermal e.m.f., (*c*) expansion coefficients. In Chapter IV plastic deformation is (somewhat briefly) touched on and experiments on gliding are included. There follows a comprehensive chapter on piezoelectricity, and this is particularly attractive. Essential electronic circuitry is described and details are given for the determination of the frequency of oscillation of a quartz plate, as well as the temperature coefficient thereof. The somewhat neglected pyroelectricity is given a complete chapter to itself (VI), and a final Chapter VII concerns measurement of elastic properties of crystals.

The whole book is a concentration of expert "know-how" and as such will be invaluable not merely to teachers and students in mineralogy, but even more so to teachers and students in physics and in electronics. The style is easy, indeed amiable, and the mathematics is reduced largely to the quoting of necessary formulae, although here and there some neat simple proofs are given. There are numerous useful worked examples which will help the student considerably.

The book is really far too useful and helpful to call for any but the smallest of criticism. The only (very minor) point seems to be the placing of Chapter VII. Surely elasticity should precede Chapter V, which deals with oscillating crystals.

It is a pity that production costs force the price up to what it is, for the book most deservedly ought to be secured by a large body of students. But as crystal physics will, in most cases, occupy but a small fraction of his syllabus, the price may regretfully prove a drawback to the undergraduate.

S. TOLANSKY

Challenger—The Life of a Survey Ship

By Captain G. S. Ritchie, D.S.O., R.N. (*London, Hollis and Carter, 1957, xxi+ 249 pp., 30s.*)

The life of this H.M.S. *Challenger*, from 1931 to 1953, is written by her last Captain but one, in command for much of a two-and-a-half-year world voyage in 1951–3 after the style of the famous *Challenger* of 1873–6. He tells of naval hydrographic survey before and during the war, of *Challenger*'s work after it upon the approaches to the new Persian Gulf oil ports, of her last long voyage of deep-sea soundings and samplings, of seismic investigation of the structure of coral atolls, and of the great deep trenches of the Pacific. He tells, too, of her company at work and at play, including an account of the magnificent first lieutenant who chalked "*Challenger*" on everything useful in sight during a dockyard refit and took delivery on board in due time by consequence. It's all very readably assembled.

W. BENNETT

Brief Notes

The British Council Annual Report, 1956–7 (1*s.*) points out that an increasing proportion of the Council's work consists in helping to disseminate knowledge about British scientific achievement, and serving as a link between scientific experts and professional bodies and their opposite numbers overseas. In the last five years the Council has assisted some 7000 visitors in the sciences, many of whom wished to survey instruments and equipment designed and built in Britain. As a result of publicity, widespread attention and respect for Britain have been secured overseas by the opening of the first full-scale nuclear-power station at Calder Hall. The Report also mentions, among other items, the overseas tours by leading British specialists, organised by the Council, and the enlarged funds granted by the Government for increased activities in the overseas information services.

LETTERS TO THE EDITOR

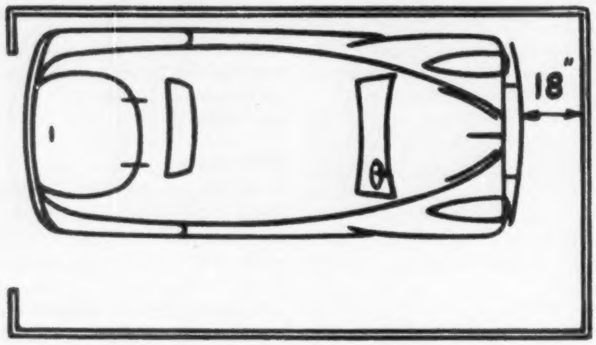
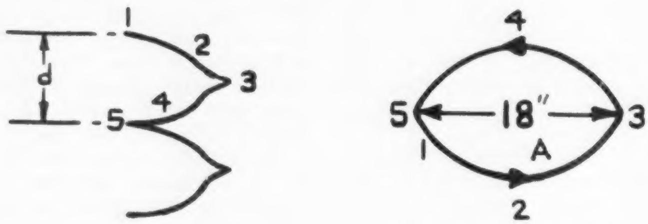


FIG. 1. Car in a garage.



(a) Path of Rear Wheels. (b) Path of Front Wheels.

FIG. 2.

A Car Parking Problem

Sir:

The problem of extricating a car parked in a garage in substantially the position shown in Fig. 1 (with only some 18 inches of end clearance) led to an interesting application of the theory of the hatchet planimeter.*

Normally, in parking or garaging a car the fundamental principle is to place the rear of the car where wanted, as subsequent manœuvres to adjust the position of the front will have only secondary effect upon the position of the rear. A further axiom is that (provided external conditions are unchanged) a car may be extricated from any position by reversing the manœuvres whereby it was placed there.

It was not possible to apply this last axiom here as I had not been the driver who garaged the car. (Out of fairness to the driver, I should state that Fig. 1 is a gross exaggeration of the position in which I found the car.) On opening the garage in the morning I found the left rear side so close to the doorpost as to run a risk of hitting it by backing; my first few preliminary moves to remedy the situation proved entirely abortive—indeed they worsened matters.

Reflection under somewhat cooler conditions suggested that a series of manœuvres (within the 18-inch limitation) to cause the front wheels to traverse a curve of the form shown in Fig. 2(*b*) should cause corresponding movements of the back wheels of the form shown in Fig. 2(*a*).

On further reflection (after successful application of the above process) I realised that the car simply acted as a large hatchet planimeter. The distance, d, gained during one manœuvre is to a first approximation A/L, where A is the area enclosed during one circuit of the front wheels, and L the length of the car wheel base. The object of the manœuvre should therefore be for the path of the front wheels to enclose as large an area as possible. Traversing an area in the reverse (clockwise) direction will, of course, cause the rear of the car to move to the left.

It is interesting to note that similar considerations, *mutatis mutandis*, apply to manœuvring the bow of a boat.

Yours faithfully,

J. G. L. MICHEL

N.P.L.
Teddington, Middlesex.

* Callender, A., *J.S.I.*, 1946, vol. 23, p. 77.

Solar Still in Antarctica

Sir:

On page 87 of the February issue of DISCOVERY [1957], there appeared an article referring to a solar still designed and manufactured by my company and operated in Mildura, Victoria.

The article was read by Mr P. G. Law, Director of the Australian Antarctic Exploration who became immediately interested in the possibility of a similar idea for use in the Antarctic during the summer months.

A streamlined edition of the small glass house still designed by our chief engineer, Mr William Donaldson, and manufactured at the company's factory at Footscray, has been completed.

The Olympic Tyre and Rubber Company has presented this still to Mr Law for use at Davis Station in the Antarctic.*

As the whole idea originated from the article which appeared in your magazine, I thought you would be interested.

Yours faithfully,

BILL FLEMING

Olympic Tyre & Rubber Co. Pty. Ltd.
Victoria, Australia.

* See p. 130.

"An Experiment and an Experience"

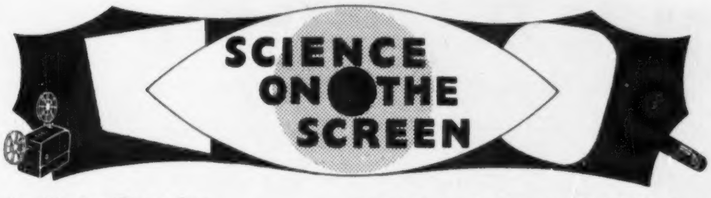
Sir:

Your correspondent J. D. Agnew (DISCOVERY, 1957, vol. 18, No. 9, p. 395) quotes Huxley as saying that God is "no longer a useful hypothesis". A self-confident small boy who took his father's car out on the road without permission would be told he was very naughty and irresponsible. Doubtless he too might feel that that was no longer a useful hypothesis! But as he grew older he might come to realise that his own self-confidence, excellent up to a point, was not a full guide to life. His father, though sometimes apparently angry, loves him. Perhaps he should try to understand and obey him.

Mr Agnew also says the orthodox religions are "in any case in process of fading out"—a statement very difficult to prove true or false. But when made in a paper like yours, it carries a certain amount of authority and influence. Where will that influence end? The point is important. Christianity, as Dean Inge said, is "an experiment and an experience". Christians are those who make the experiment and discover the experience of a moral God who loves and guides; but we realise there can be no slick and easy proof of this. But if this letter can make even one reader hesitate about swallowing Mr Agnew's camel, it will have served its purpose!

B. KIRKPATRICK

8A Lefroy Street,
Coatsbridge, Lancs.



Television During December

During the month of December only the BBC presented science programmes on television. As a compensation for their absence on the alternative bands, four ITV broadcasts for January have been produced (Mondays at 11 p.m.), entitled "Conquest of Space", to be reviewed at a later date. The BBC weekly series, "Eye on Research" (Thursdays at 10.35 p.m.), will continue, leaving us in the happy position of seeing two late-night broadcasts each week on scientific subjects. This is an enormous improvement on late autumn last year, during which the weeks passed steadily without a single adult science television broadcast. We hope the improvement will be maintained.

The BBC December broadcasts consisted of a continuation of the series, "Eye on Research" (numbers 3, 4, and 5), and their regular monthly item, "Sky at Night". "Eye on Research", after a flying start, has slowed down disappointingly; indeed it was a very lame runner on December 12. The programme on that date, devoted to neurological studies, and in particular to electroencephalography, was so confusing to the viewer, so disjointed and so befogging, that it is kinder to make no further comment on it at all.

December 19 saw Number 5 in the series, the last to be given in 1957; the subject, "Trial by Water". This involved the now familiar technique of an outside broadcast visit to a large research establishment with interviews of important experts carried out by Robert Reid. The establishment selected this time was the large Hydraulic Research Station at Wallingford. It would appear that the main object of the visit was to illustrate how large models of coastal and river basin areas are used to investigate water-erosion effects. This time we had a good performance by the expert being interviewed. There was, however, one curious feature in production which was an appreciable deviation from what one might have expected from a subject ostensibly devoted to research. An admirable scientific demonstration from a wave-making machine was followed by an appreciably long film sequence of a fishing port. Now, while this film was undoubtedly of human interest, any really practical connexion with research was completely absent. Of course, hydraulic research improves port facilities, but we were left to guess at this from the fishing-port scenes, excellent in themselves, but nothing to do with research.

One quite minor slip-up was the fact that although there was a useful discussion on the importance and value of radioactive tracers in following water-erosion effects, there was no explanation at all of what a radioactive tracer is and how it works. One cannot insist too often on the absolute need for simplifying careful explanations of *any* technical terminology when used in a popular broadcast. It is fatally easy to assume a knowledgability in the viewer which in fact does not exist. This emphasis on a mere detail may look very much like making a mountain out of a mole-hill, but "details make perfection, and perfection is no detail".

One regrettable approach by Robert Reid (not for the first time) is the way in which this commentator tends occasionally to emphasise the "cash value of research". Surely this might give a very false impression of the real motivation and true driving forces behind what really matters, after all, namely the pure fundamental researches in all disciplines. It will be unfortunate if the general viewing public acquire the impression that the prime purpose of scientific research is merely the improving of technical and economic efficiency, and some of Robert Reid's closing comments sound dangerously like this.

The best broadcast of the month was undoubtedly Patrick Moore's December 14 broadcast on "Sky at Night". Exploiting the fact that Venus was to be at its brightest on Christmas Eve, Mr Moore took Venus as his theme, and considering its striking brilliance at the time of the broadcast, nothing could have been more appropriate. Beginning with a beautiful Mt Palomar picture of Venus in crescent, there followed admirably clear animated diagrams illustrating the development of the phases of the planet. Then Mr Moore gave a witty, amusing, and yet very informative account of theories of the planet's atmosphere. The talk ended with an excellent comparison between the real sizes of the red giant Betelgeuse and of Venus. It was altogether an excellent fifteen minutes, full of detailed information yet suitably leavened and not overloaded.

S. TOLANSKY

Test Flight 263

Produced by Ronald Riley. Written and directed by David H. Villiers. Black and white; running time, 38 minutes. An RHR Production.

This is a panorama of aircraft research. Fitted into the frame of a routine flight, the story concerns the testing of the power-controls at Mach 2 of a Fairey Delta aircraft. All important aspects of present-day aeronautical research are touched on. The problems of a designer are discussed; wind tunnels, both sub-sonic and supersonic, are beautifully photographed; metal fatigue, gas turbines, aircraft fuels, and aviation medicine pass by in a rapid stream of pictures.

The value of the film depends directly on the previous scientific and technical knowledge of the audience. Scientists interested in the subject of aeronautical research will be greatly delighted in seeing the many laboratories in which current research is being carried out. But for those to whom science is a closed book the film will not mean more than a bewildering array of dials, machines, and serious-looking young men and women. However, there can be few, particularly among the younger generation, who will not have a sufficient basic understanding of what aircraft are and what makes them fly, to miss the enjoyment of this kaleidoscopic picture changing so rapidly and yet with an underlying logic.

A. R. MICHAELIS

Films and Automation

The Scientific Film Association organised for Messrs Tecalemit a meeting on *Films and Automation* in Plymouth on Friday, November 8, 1957, which was attended by over 320 representatives from industry and education in the south-west.

The chairman was Mr T. R. Hardman, General Manager of Tecalemit Ltd, and the subject was introduced by Mr R. J. Cowie, A.M.I.Mech.E., of the Production Engineering Research Association. Mr Cowie outlined the main technical developments in the field of automation and discussed some of their social implications. He illustrated his talk with three films—*This is Automation* (G.B. Film Library, 29 minutes), a film surveying the development of automatic processes and methods in the United States; *The Electro-Mechanical Head* (Sentinel, Shrewsbury Ltd, 25 minutes), a film produced by the Renault Car Company in Paris to illustrate the principles and varied applications of their electro-mechanical head units in France, Italy, and Spain; and *Numerical Control* (Ferranti Ltd, 20 minutes), describing Ferranti's system of computer control of machine tools.

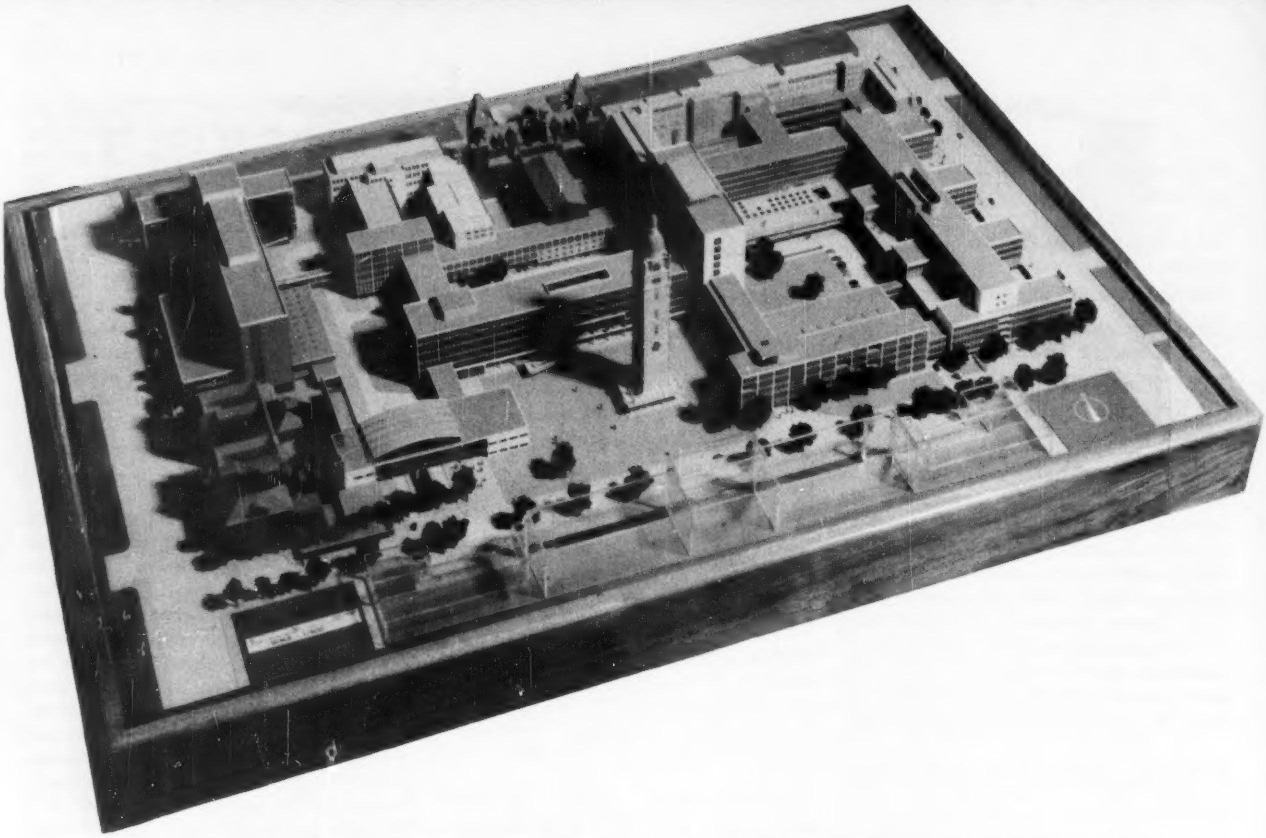


FIG. 1. Model of the revised plan for the development of the Imperial College central spire. The Royal School of Mines building, designed by Aston Webb, and the new building for Chemical Engineering and Aeronautics, designed by Norman and Dawbarn, have been incorporated in the scheme, along with certain independent buildings, notably the Royal College of Music on the north side. The buildings will accommodate 3000 students and will have a daily population of more than 4000 people. Architects are Messrs Norman and Dawbarn.

FAR AND NEAR

Imperial College Expansion

The number of full-time students at the Imperial College of Science and Technology has risen by 235 since 1956 and now stands at 2450. Since the College's expansion programme was started in 1953 the number of students has increased by 800. This was announced by the Rector, Dr R. P. Linstead, at the College's Commemoration Day ceremony held at the Royal Albert Hall. Dr Linstead added that no less than fifteen new Professorships and Readerships in the University of London have been established and filled at the College in the past twelve months. Plans for new Halls of Residence were well advanced; approval had just been received for the clearance of existing derelict properties on the south and east and part of the north sides of the neighbouring Princes Gardens to make way for the new Halls, among which is to be Weeks Hall, for which a gift of £150,000 by Messrs Vickers Ltd was announced in March last year.

The National Research Council of Canada

The Department of Scientific and Industrial Research represents the approximate English equivalent of the National Research Council of Canada. The NRC is divided into a number of divisions dealing with such subjects as Applied Biology, Prairie Regional Laboratories, Applied Chemistry, Applied Physics, Building Research, Mechanical Engineering, and Radio and Electrical Engineering. The headquarters organisation deals with Public Relations, Scientific Liaison, and Technical Information. It has an active publications section which issues a very complete annual review of the Council's work, detailed lists of activities in scientific research and Canadian industry, lists of the research subjects of individual scientists, and guides to the laboratories, together with general publications about the individual divisions.

The Council was founded in 1916 and was organised to have two functions: firstly, to stimulate all phases of scientific research in Canada; and secondly, to link science with industry. The Montreal site of the NRC now comprises 400 acres, and houses many of the divisions in engineering, biology, physics, and chemistry named above. The Ottawa and Montreal sites together constitute probably one of the largest research establishments in the world.

The Council's work has proved of great profit to Canadian industry and a very wide variety of subjects has been investigated.

It is hoped that from time to time DISCOVERY may be able to publish items of interest from this very active and extremely large research organisation.

The Electronic Thom(p)sons

Prof. J. T. MacGregor-Morris has written to point out to us that we have unintentionally committed the only too common error making Sir J. J. Thomson into a Thompson. Elsewhere we have been diligently and carefully correct with

members of both sides of this clan, but for once the hazards of proof-reading defeated us (DISCOVERY, 1957, vol. 18, No. 6, p. 243), and we hasten to admit our guilt and add our voice to the plea for proper treatment of this distinguished company of electrical scientists.

- Sir J. J. *Thomson* of the Cavendish Laboratory, Cambridge.
- Prof. William *Thomson,* later Lord Kelvin.
- Prof. Elihu *Thomson,* of U.S.A. (and in B.T.H.).
- Count Benjamin *Thompson,* later Count Rumford.
- Prof. Silvanus P. *Thompson,* Principal of Finsbury Technical College and authority on the history of electricity and magnetism.

There are, of course, other Thom(p)sons in other scientific fields and doubtless more will be coming to confuse us. Perusal of a recent biographical register indicates that the ratio of P to non-P is about five to one, but clearly the electrical proportions are anomalous.

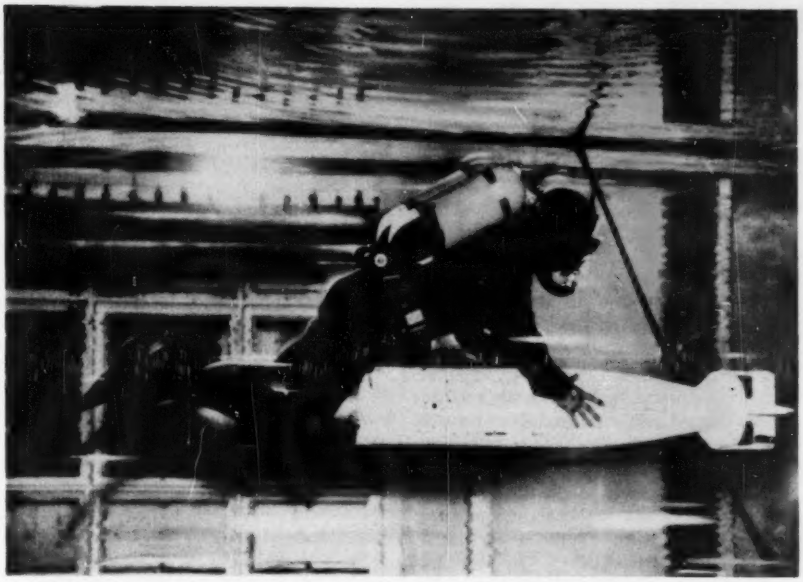


FIG. 2. A frogman scientist making an adjustment to a torpedo in a million-gallon water tank. The water is clear enough to allow photographs, taken at one 40,000th of a second, of missiles travelling at speeds up to more than 100 knots (115 m.p.h.).

Clear Water for Photography

The increasing use of underwater photography for industrial and scientific research has created a demand for water purification plant capable of maintaining large quantities of water permanently at optical clarity.

An interesting installation of this type is in operation at the Admiralty's research laboratories at Teddington. It serves a water tunnel with glass panels through which water can be watched flowing past models at speeds of up to 50 knots, a glass-sided tank for the study of the trajectories of bodies, and a rotating beam channel containing more than a million gallons of water in which submerged bodies can be towed in a circular path at speeds up to 100 knots. The behaviour of many of the fast-moving models is studied with the use of high-speed photography and the water is so pure that a submerged object can be seen quite clearly 100 ft. away.

The filtration system works by continuously removing the surface layer of water which is most likely to become contaminated, and by completely transferring

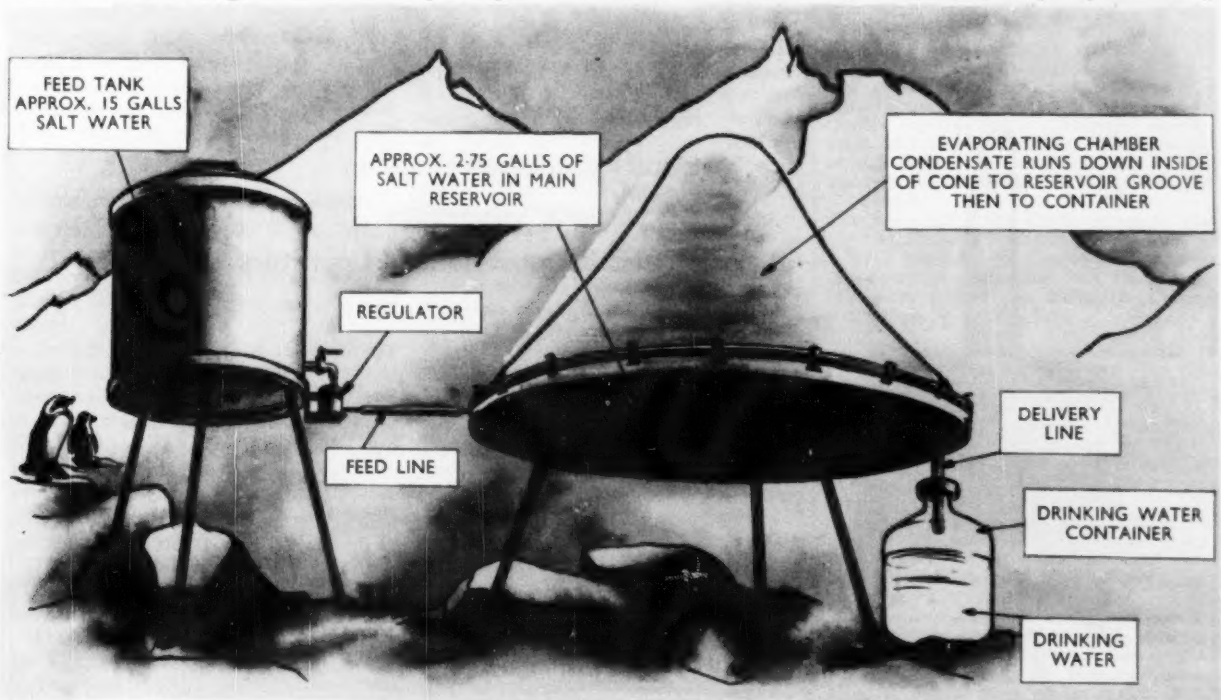


FIG. 3. Solar still for Antarctic (see pp. 126 and 130).

the entire mass of water through the filters without leaving any stagnant pockets.

The filtering unit consists of three Pulsometer 8-ft. diameter pressure sand filters which have a maximum filtration rate of 250 gal. per hour per sq. ft. The internal surfaces of the welded steel plate shells are coated with special corrosion-resisting material, and the filter medium is supported upon steel grid plates. There are no moving parts in the filter to rust or fracture.

The necessary floc on the surface of the sand is formed by dosing with special chemicals, some of which are also used to maintain the pH value at approximately 7·4. A standard automatic vacuum chlorinating unit serves to prevent organic growth.

The equipment has sufficient pumping capacity to allow double the filtration flow, which gives it flexibility and an adequate margin. If desired a portion of the flow can be made to by-pass the filters thus increasing the general water movement without raising the duty of the filters.

The filter vessels are washed by reversing the flow in the customary manner and the sand bed is gently agitated with compressed air. The contents of the water tunnel can be filtered independently by means of a separate flow and return main.

Solar Still for Australian Antarctic Expedition

The sun's rays will be used to provide fresh drinking water daily for four men stationed at an isolated Antarctic station in the Vestfold Hills, Australian Antarctic Territory. The four men manning Davis Station, situated in a barren area of ice-free rock covering 300 square miles, will use a cone-shaped Perspex solar still designed by Mr William Donaldson, chief engineer of the Olympic Tyre and Rubber Company, and manufactured at Footscray by the Company. The still will be presented to Mr P. G. Law, Director of Antarctic Exploration, by the Company as a contribution towards the research of the CSIRO on solar energy devices.

Originally developed with the advice of the CSIRO to procure pure water from brackish bore water in the outback, the solar still was first used at Mildura to distil water for car batteries. This experiment attracted world-wide interest and Mr Law suggested the solar still could be the answer to the problem of supplying fresh drinking water from the sea in the Antarctic, during the summer months when the ice and snow had melted. He said the present method of obtaining drinking water was by an electrical distilling plant, which imposed an undue load on the electric generating plant at the station.

The solar still, which needs no mechanical aid, can be dropped by parachute and erected in thirty minutes. It has been especially designed for the Antarctic and is a compact piece of equipment. It operates very efficiently in the Antarctic during the summer when there are twenty-four hours of daylight and produces two gallons of fresh water each day. Once erected, the solar still presents no mechanical problems, and the only maintenance is occasional cleaning, a two-minute task.

Signal Honour for NRC Scientist

Dr Gerhard Herzberg (Director, Division of Pure Physics, National Research Council of Canada) has been elected an Honorary Fellow of the National Academy of Sciences, India.

Erratum: Owing to an oversight, no acknowledgment was made of Fig. 1 on page 11 (DISCOVERY, 1958, vol. 18, No. 1) in Prof. S. Tolansky's article, *Diamond: Fiction, Fancy, and Fact.* It was reproduced, by kind permission of the Editor, from a special supplement of the *Industrial Diamond Review* (February 1953, p. 3).

Encouraging Scientific Talent

A research programme to investigate the patterns of creativity in the sciences has been established by New York University's Division of General Education. Directed by Adjunct Prof. Myron A. Coler, it will be concerned with the recognition and encouragement of scientific talent.

A series of seminar meetings, to begin at NYU early in 1958, is one of the first projects of the programme. Plans also are being made to publish the findings of the seminars. The participants will be research workers and research managers from government, industry, and the University. Using an operational approach, they will seek to arrive at ways of dealing with creativity, to delineate creative research patterns, and to foster inter-science research projects. The subject of the first seminar will be "The Role of Conjecture".

Participation in the series will be by invitation, but—according to Dr Coler—interested persons should feel free to write to him at NYU's Division of General Education, Washington Square, New York City.

Another project of the Creative Science Programme will be the establishment of a specialised reference library to collect and codify the extensive but scattered literature pertinent to creativity in the sciences. Annotated bibliographical material also will be published.

According to Dean Paul A. McGhee of the Division of General Education, the new Creative Science Programme is "dedicated to the belief that our creative talent is the single most valuable resource of our country and that its adequate conservation and cultivation is one of our most important educational needs and responsibilities".

International Prize to Bertrand Russell

The Kalinga Prize for the popularisation of science, offered annually by Unesco, has been awarded for 1957 to Bertrand Russell, British philosopher, scientist, and writer.

Kalinga is the name of a foundation which contributes to the economic development and the social and cultural progress of the Indian State of Orissa. The Kalinga Prize of £1000 is offered in recognition of the work of leading interpreters of science in an endeavour to strengthen the links between India and scientists of all nations.

The prize fund is a personal donation of Mr B. Patnaik, a member of the Legislative Assembly of Orissa.

The foundation derives its name from the Kalinga empire, which stretched over a great part of India and Indonesia. The empire was conquered by the great sovereign, Asoka, more than 2000 years ago, but the campaign gave him such a distaste for war that he spent the rest of his life in working for peace.

Nominations for the recipient of the Kalinga Prize are received each year from various scientific groups directly interested in the popularisation of science and particularly from national associations for the advancement of science and national associations of science writers.

In 1957 there were seven candidates presented by associations in France, the Federal Republic of Germany, Italy, United Kingdom, United States, and Venezuela.

The nominations were considered by an international jury composed of Prof. Marcel Florkin, biochemist, President of the Association Belge pour la Diffusion de la Science; Mr L. J. F. Brimble, Editor of *Nature*; and Prof. J. L. Jakubowski, member of the Academy of Science of Poland.

Bertrand Russell, selected by the jury as 1957 prize-winner, was nominated by the Venezuelan Association for the Advancement of Science.

The five previous winners of the Kalinga Prize have been Prof. Louis de Broglie (France), 1952; Dr Julian Huxley (United - Kingdom), 1953; Waldemar Kaempffert (United States), 1954; Dr August Pi Suner (Venezuela), 1955; and Prof. George Gamow (United States), 1956.

Leader for 1958 Mawson Party

Mr Ian Leonard Adams, of Mitcham Road, Mitcham, Victoria, has been selected as officer-in-charge of the 1958 Australian National Antarctic Research Expedition to Mawson. This has been announced by External Affairs Minister Mr Casey. Mr Adams, who was born in New Zealand in 1925, was officer-in-charge of the 1956 Australian party at Macquarie Island. He was a member of the New Zealand Air Force during the Second World War, and has had considerable experience in mountaineering and deep-sea yachting. The expedition will sail from Melbourne late in December.

"Space Law" Committee to be Formed

The International Astronautical Federation, at its meeting in Barcelona, decided that a committee of leading scientists should be set up to prepare a list of recommendations for laws to govern outer space. The recommendations will be submitted to the United Nations Organisation. The chairman of this committee is Prof. John Cobb Cooper. Legal representatives from the British Interplanetary Society, the American Rocket Society, and the Deutsche Gesellchaft für Raketentechnik und Raumfahrt will also serve on the committee.

SCIENTIFIC OFFICERS required by MINISTRY OF SUPPLY at research and development establishments mainly in south of England, for work in physics, electronics, electrical mechanical or aeronautical engineering, applied mathematics, metallurgy, or chemistry. Qualifications: first- or second-class honours degree in appropriate subject, or equivalent. Candidates should indicate fields of work in which interested. Starting salary in range £595 to £1080 p.a. (superannuable) according to research experience. Rates for women somewhat lower but reaching equality in 1961. Forms from M.L. & N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.8/8A.

TAXONOMIC BOTANISTS

FLORA OF TROPICAL EAST AFRICA

VACANCIES exist for TAXONOMISTS to work on this Flora at the Royal Botanic Gardens, Kew. Appointments will be made in the Scientific and Experimental Classes according to qualifications. Previous postgraduate taxonomic experience not essential since probationary training period can be provided. Posts are unestablished but F.S.S.U. available for Scientific Class.

Salary up to £2050; starting salary according to qualifications and experience.

For further particulars and application forms write to Under-Secretary of State, Colonial Office, S.W.1, quoting RES.134/6/02.

APPOINTMENTS VACANT

INFRA-RED SPECTROSCOPIST

COURTAULDS LIMITED has a vacancy in its Fundamental Research Laboratory at Maidenhead for a PHYSICAL CHEMIST or PHYSICIST with experience, or at least an interest in infra-red techniques as applied to high polymers. Research experience in this field preferred but not essential. The work would be entirely confined to spectroscopy.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St Martins-le-Grand, London, E.C.1, quoting reference number D.82.

LABORATORY TECHNICIAN (man or woman) required at Furzedown Training College for Teachers, Welham Road, S.W.17. Duties mainly in Biology, including some work with animals. Some experience desirable, but applicant in training might suit. Salary—£245 a year at 16 rising to £490. Additional increments for specified qualifications up to £577. Further particulars and application forms (returnable within 14 days) from Principal. (197)

MICROBIOLOGIST

COURTAULDS LIMITED has a vacancy for a MICROBIOLOGIST in its newest Coventry Research Laboratory. Candidates should possess an Honours Degree in Chemistry with, preferably, Bacteriology, Microbiology, or other biological subject as a subsidiary or postgraduate qualification. The work involves microbiological and chemical investigation of a wide range of problems encountered in the Textile Industry. Age 25–32.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St Martins-le-Grand, London, E.C.1, quoting reference number D.77.

TRAIN TO TEACH SCIENCE SUBJECTS

EXCELLENT CAREER PROSPECTS

Applications are invited from men and women for TRAINING as

FULL-TIME TEACHERS OF SCIENCE in TECHNICAL COLLEGES AND SCHOOLS

The next course of training will begin in SEPTEMBER 1958 and end in JUNE 1959

Applicants should normally all
(1) be between about 25 and about 45 years of age;
(2) have industrial experience;
(3) possess one of the following:
Higher National Certificate;
Higher School Certificate;
Professional qualification or degree.

MAINTENANCE GRANTS AVAILABLE
NO TUITION FEES

Write for details and an application form to one of these colleges:

The Director (S/1/17),
Bolton Training College,
Manchester Road, BOLTON.

The Principal (S/1/17),
Garnett College,
83 New Kent Road, LONDON, S.E.1.

The Director (S/1/17),
Huddersfield Training College,
Queen Street South, HUDDERSFIELD.

SCHOLARSHIPS

THE NUFFIELD FOUNDATION
SOCIOLOGICAL SCHOLARSHIPS AND BURSARIES

THE NUFFIELD FOUNDATION, in pursuance of its programme for the advancement of sociological studies, is prepared to offer for the academic year 1958–9 a small number of scholarships and bursaries to enable graduates in academic subjects other than the social sciences, psychology or economics, to study the social sciences. The Foundation's particular object is to enable men or women, who are already well qualified in other disciplines, particularly the natural sciences or the humanities, to receive a training in, for example, political science, social psychology, anthropology, social statistics, and sociology generally (but not economics) so that in due course they may undertake research or teaching in the United Kingdom in those subjects. *The scholarships*, which are the senior awards, are intended for persons who have already undertaken some postgraduate work in their own subject. *The bursaries* are intended to enable those who have recently graduated to take a course of training in sociological subjects. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1958 must be received before May 1, 1958, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN,
Director of the Nuffield Foundation.

THE NUFFIELD FOUNDATION
BIOLOGICAL SCHOLARSHIPS AND BURSARIES

THE NUFFIELD FOUNDATION, as part of its programme for the advancement of biological studies, is prepared to offer for the academic year 1958–9 a limited number of scholarships and bursaries to enable persons who have graduated in physics, chemistry, mathematics or engineering, but who have had no training in a biological subject, to receive such training in biology as will enable them in due course to undertake research and teaching in the United Kingdom in the biological sciences. *The scholarships*, which are senior awards, are intended for persons who have already undertaken some postgraduate research in their own subject. *The bursaries* are intended to enable those who have recently graduated to complete a course of training in biological subjects including, if considered necessary, a full honours degree course in biology. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1958 must be received before April 1, 1958, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN,
Director of the Nuffield Foundation.

LECTURES AND COURSES

"PROBLEMS OF HANDLING LARGE MISSILES", by F. R. F. Taylor, April 5, 6 p.m., Caxton Hall, London, S.W.1. Admission tickets and copy of full programme and membership details obtainable from the Secretary, BRITISH INTERPLANETARY SOCIETY, 12 Bessborough Gardens, London, S.W.1.

FARADAY HOUSE
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A THREE-YEAR COURSE, commencing each term, in Electrical Engineering to qualify for Associate of Faraday House and Graduate of the Institution of Electrical Engineers, followed by one year's practical training in Industry to qualify for the Diploma of Faraday House. For Prospectus apply to Department "E", Faraday House Electrical Engineering College, 66 Southampton Row, London, W.C.1.

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